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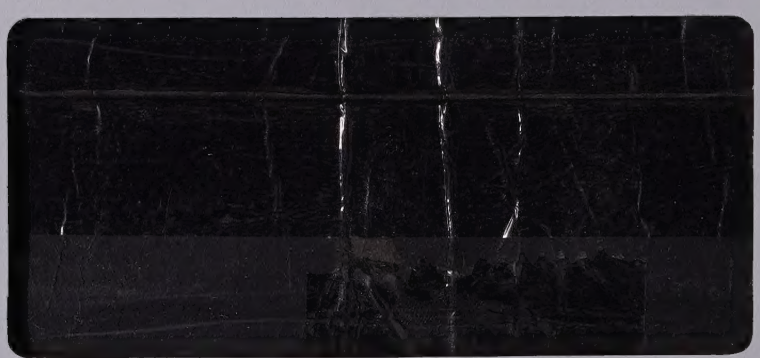

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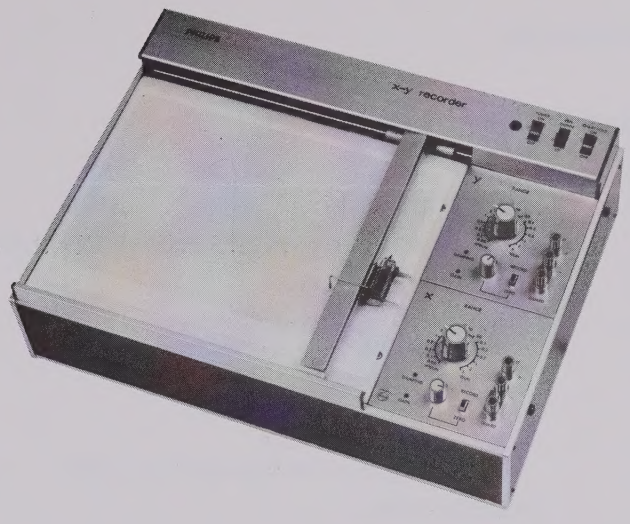


# Manual

X-Y FLAT BED RECORDER

## PM 8120

9499 430 01211

15/471

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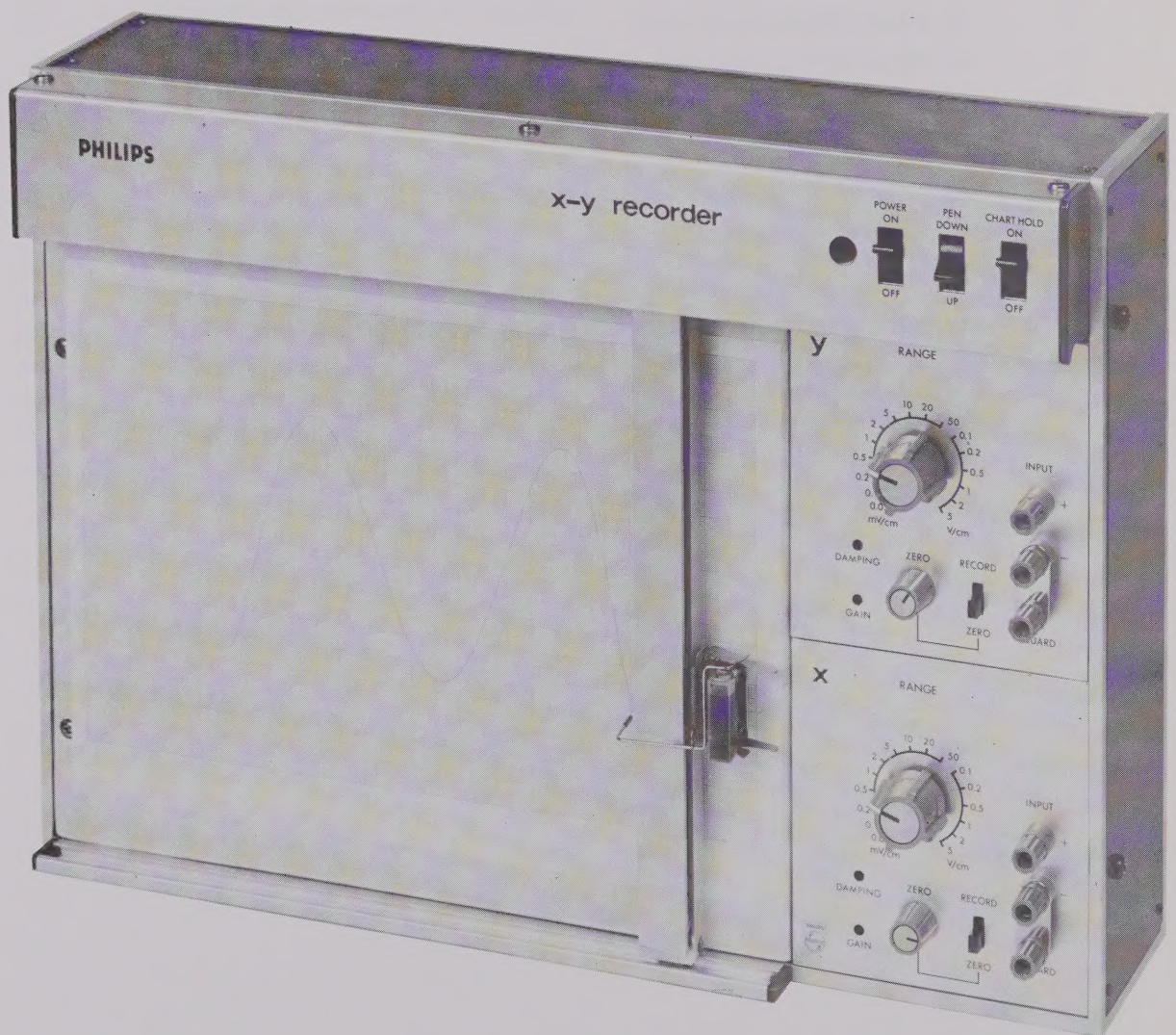

PHILIPS
x-y recorder
POWER ON
OFF
PEN DOWN
UP
CHART HOLD ON
OFF
y
RANGE
mV/cm
V/cm
INPUT
DAMPING
ZERO
RECORD
GAIN
ZERO
x
RANGE
mV/cm
V/cm
INPUT
DAMPING
ZERO
RECORD
GAIN
ZERO

# DIRECTIONS FOR USE

## I. INTRODUCTION

The PHILIPS X-Y flat bed recorder PM 8120 is a highly accurate, highly sensitive instrument, meant mainly for recording two mutually dependent quantities (y=f (X) ), the independent variable being the horizontal axis and the dependent variable the vertical axis.
The instrument can be used in an almost unlimited range of applications, e.g., recording B-H curves of magnetic materials, characteristic curves of vacuum tubes or semiconductor devices, stress-strain diagrams, sampling scope curves, damping curves of band filters etc.
In short, it is able to record any quantity that can be converted into a d.c. signal.

Special features of the PM 8120 are:
High stray-voltage rejection ratio, full scale zero positioning, remote control pen lift, and an electrostatic chart hold-down system which, in combination with two pin-point lights in the chart table, enables quick and easy fitting or replacement of any type of chart paper, up to DIN-A4 format.

The recorder operates on the principle of automatic compensation of the quantity to be recorded, by means of two servo-systems.

The instructions in the first part of this manual are arranged in the sequence of the operations to be performed when preparing the instrument for use.

THE READER IS ADVISED TO PAY CAREFUL ATTENTION TO THESE INSTRUCTIONS, since by doing so he will be better equipped to exploit the full potential of the instrument and also to minimise the likelihood of defects.

Although the instrument has a very high M.T.B.F. (Mean Time Between Failures) of 2000 hours, maintenance is required from time to time.
Therefore, special attention should be paid to the chapter on MAINTENANCE.

## II. STANDARD ACCESSORIES AND REMOVAL OF TRANSPORT SECURITY DEVICE

The following standard accessories are supplied with, but not fitted to the recorder:

1. Service kit, containing:
– two writing systems and two bellows
– bottle of oil (Shell Tellus 27)
– brush, for lubrication of parts with the oil supplied
– cross-head screwdriver
– thermal fuses: 2x 0.5 A/220 V; 2x 1A/110 V
– ink set PM 9810, consisting of:
10 cartridges with red ink
5 nylon pen tips
1 special tool, for fitting and removing pen tips
– ink set PM 9811, consisting of:
10 cartridges with green ink
5 nylon pen tips
1 special tool, for fitting and removing pen tips

2. Fifty sheets of squared graph paper (obtainable in any bookshop and therefore not to be re-ordered).

3. Dust cover.

The following are mounted on the recorder:

a. Bracket (bail tilt), used for positioning the recorder at an angle of approx. 15°.
b. Plug for connecting the remote control cable of the pen lift mechanism.

TRANSPORT SECURITY DEVICE

To prevent damage to the measuring carriages during transport, these are locked by a bracket.

BEFORE THE RECORDER IS CONNECTED TO THE MAINS AND PUT INTO USE, THIS BRACKET MUST BE REMOVED IN ORDER TO PREVENT DAMAGE TO THE DRIVE MECHANISM.

To remove the bracket, loosen the screw (fig. 2; item 1). After removing the bracket (fig. 2; item 2), re-insert the screw.

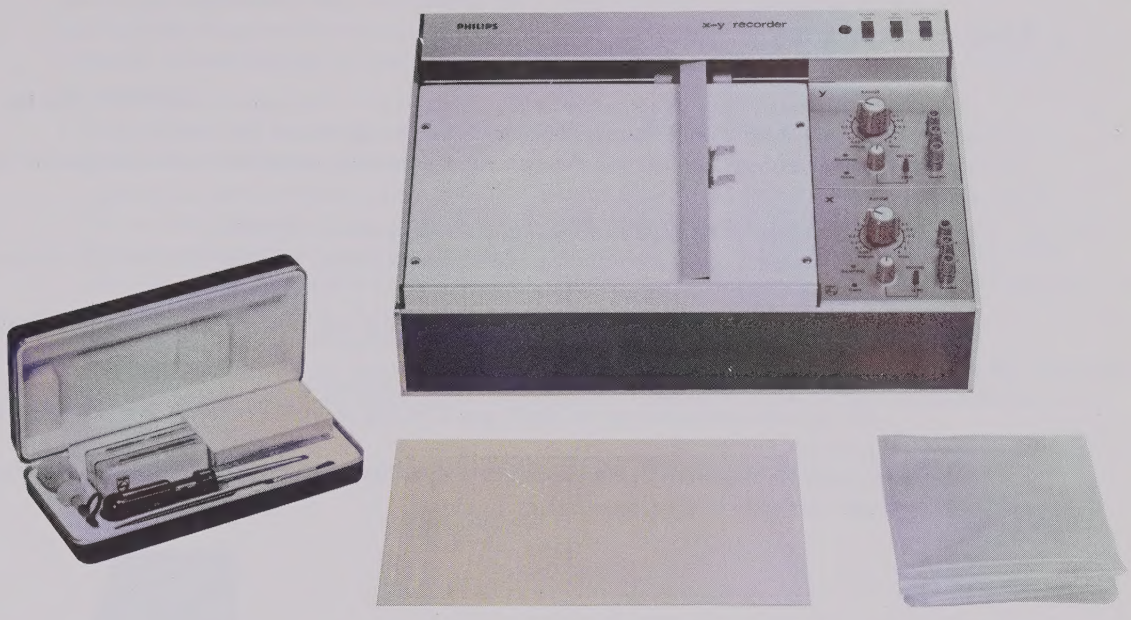

PHILIPS
x-y recorder

*Fig. 1*

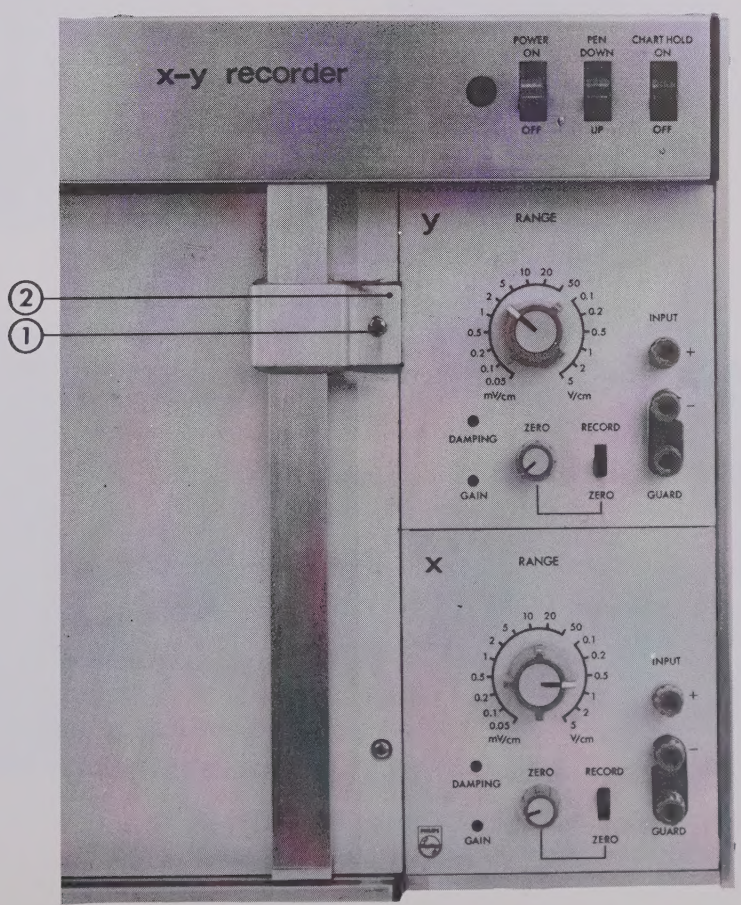

x-y recorder
POWER ON
OFF
PEN DOWN
UP
CHART HOLD ON
OFF
y
RANGE
10 20
5
2
1
0.5
0.2
0.1
0.05
50
0.1
0.2
0.5
1
2
5
mV/cm
V/cm
INPUT
+
−
DAMPING
ZERO
RECORD
GAIN
ZERO
GUARD
x
RANGE
10 20
5
2
1
0.5
0.2
0.1
0.05
50
0.1
0.2
0.5
1
2
5
mV/cm
V/cm
INPUT
+
−
DAMPING
ZERO
RECORD
GAIN
ZERO
GUARD
2
1

*Fig. 2*

## III. CONNECTION DATA

### A. MAINS VOLTAGE AND EARTHING

Check that the mains voltage adaptor switch (fig. 3, item 1) is in the correct position and that the termal fuse (fig. 3, item 2) is of the correct value (0.5 A for 220 V; 1 A for 110 V).
The recorder should be connected to a rim-earthed mains socket, using the (EURO) universal contact plug supplied.

*NOTE: The instrument is supplied to operate at a mains frequency of 50 Hz.*
*If the recorder is to be connected to a 60 Hz mains system, the hum filter must be switched over as follows:*

- Loosen the fixing screws (fig. 4, item 1 and 2 for X and Y resp.) and withdraw the input units.
- Disconnect the plugs from these units.
- Loosen the screw, fig. 5, item 1 and remove the screening plate, item 2.
- Set the sliding switches (fig. 6, item 1 and 2) to the required positions, as indicated on the printed wiring board.

The recorder is again ready for use once the input units have been replaced by performing the above operations in the reverse order.

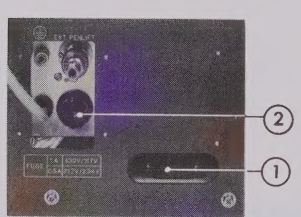



*Fig. 3*

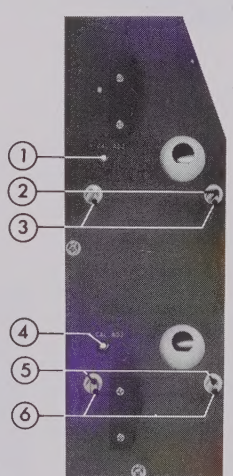



*Fig. 4*

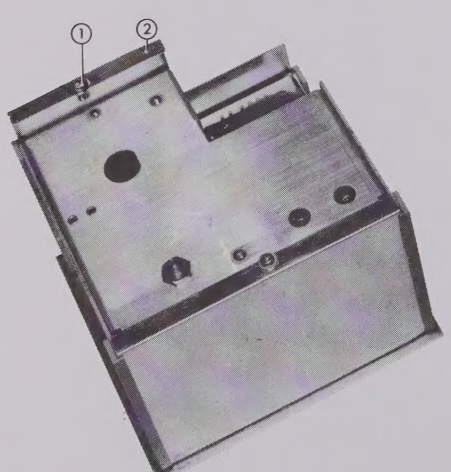



*Fig. 5*

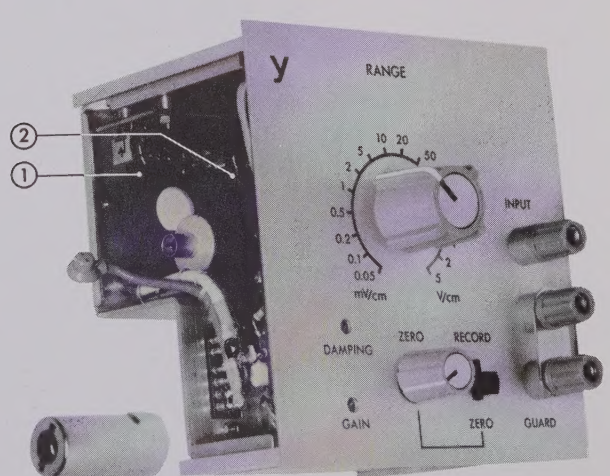



*Fig. 6*

## B. EARTHING THE INPUT CIRCUIT

The voltage source or transducer should be connected to the recorder using a 2-core screened cable; the use of unscreened cables may cause interference signals to affect the measuring results.
Earthing the voltage source or transducer can be accomplished in more than one way, therefore it is advisable to determine the best method of earthing by experiment. In the following, some methods are suggested.

1. In most cases, the measuring cable screen should be connected to the measuring earth terminal, indicated by "GUARD". This terminal is connected to the housing of the input unit and, via a capacitor, to the instrument earth. Since the housing of the input unit is isolated from the rest of the recorder, the entire input circuit is floating with respect to earth for d.c. signals. (see also fig. 9a).
2. When the voltage source is at the same level as the screening, e.g. when the source is earthed at the spot (see fig. 9b), the negative terminal of the recorder can be connected to the "GUARD" terminal using the hinged strip (fig. 7, item 1).
   Connect also the measuring cable screen to the "GUARD" terminal.
3. If it is desired to earth the measuring circuit and/or the screening (see fig. 10a, b), connect the "GUARD" terminal to the instrument earth socket (fig. 8, item 1). The input circuit is then earthed via the earth-rim of the mains plug.

*NOTE: To prevent earth loops, the measuring circuit should be earthed at one point only.*

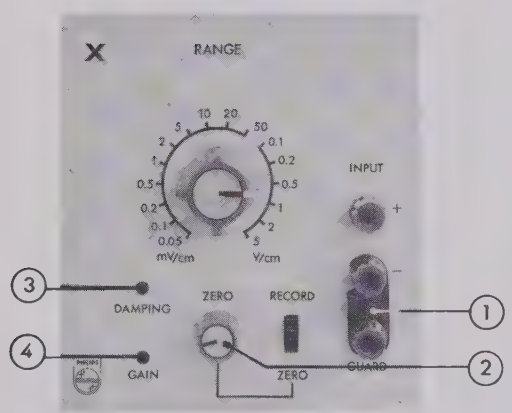



*Fig. 7*

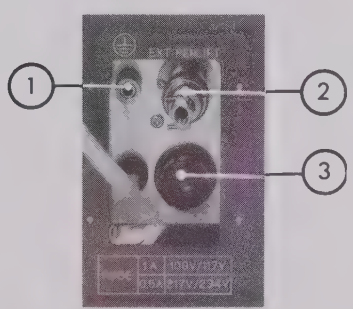



*Fig. 8*

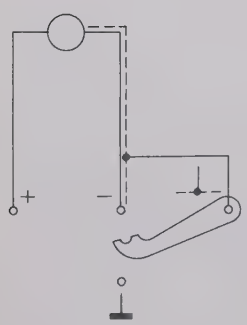


*Fig. 9a*

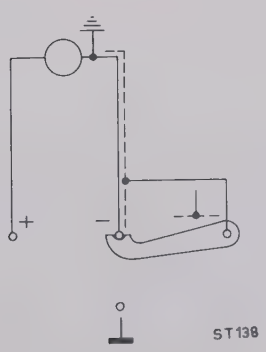



*Fig. 9b*

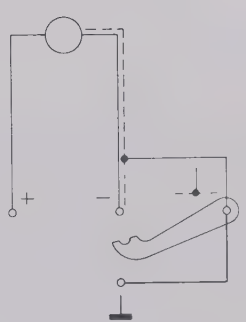


*Fig. 10a*

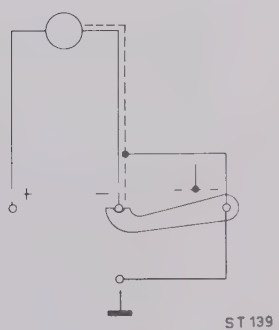



*Fig. 10b*

## C. mV-MEASUREMENTS

The positive and negative terminals of the voltage source must be connected to the recorder terminals marked "+" and "–" by a 2-core screened cable.
For earthing, see under "B. Earthing the input circuit".

## D. TEMPERATURE MEASUREMENTS

These measurements must be carried out with thermocouples. Distinction must therefore be made between the following cases:
– cold junction at 0 °C, or at another constant temperature.
– cold junction at room temperature.

In the first case, the thermocouple (whether or not extended by a compensation cable), must be connected to the recorder by a screened cable with copper cores, as indicated in fig. 11.
The cold junction can be in a container with melting ice, or in another environment at a constant temperature.
For connection of the screening of the measuring cable, the instructions in "B. Earthing the input circuit" apply.
The temperature to be measured is determined by converting the indication in mV into °C (using the °C/mV-conversion table of the thermocouple employed) and adding the temperature of the cold junction.

In the second case, the thermocouple (whether or not extended by a compensation cable) can be connected as follows:
– Directly to the input terminals; the cold junction then being at the recorder terminals.
– By a screened measuring cable with copper cores to the input terminals; the cold junction then being outside the recorder.

The temperature of the object is again determined by converting the indication in mV into °C, adding the room temperature, which is, in practice, that of the cold junction.

*NOTE: If a compensation cable is used, be sure to connect the correct cores of thermocouple and compensation cable.*

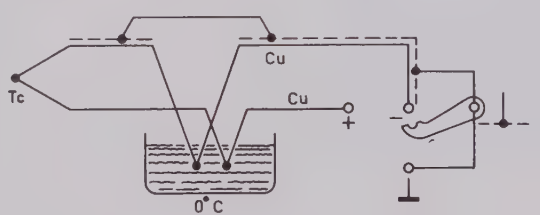



*Fig. 11* ST 140

## E. CURRENT MEASUREMENTS

If the pattern of a current is to be recorded, the current must be converted into a voltage suitable for the recorder. Two cases can here be distinguished:

1. The current from a current source (for example, an instrument with a current output) is to be measured. To ensure minimum load on the current source, it must be terminated with the smallest possible series resistance. The recorder is switched to the most sensitive range (0.05 mV/cm) and the resistor calculated to give the scale deflection desired (Ohm's law).
2. The current in a circuit is to be measured. Generally, the circuit incorporates a resistor across which the voltage can be measured directly.
   The current through the resistor can then be calculated by Ohm's law. This method of working is very accurate, since the input impedance of the recorder is high.
   If it is not possible to measure the voltage across an existing resistor, connect a resistor of the smallest possible value in series. This resistor must be calculated to give the scale deflection desired on the most sensitive range of the recorder.

## F. MEASUREMENTS WITH SUPPRESSED ZERO POINT

If small variations of a relatively high voltage are to be measured, the zero point must be suppressed. This can be done by connecting another voltage source of reversed polarity and precisely known level in series with the voltage source to be measured.
The recorder then records the voltage difference of the two sources.
A recommended source for this purpose is the Philips' PT 2248, a highly stable and accurate voltage and current reference unit.

When this instrument is used, the accuracy and damping of the system are not affected.

*NOTE: As stated in chapter VII. TECHNICAL DATA, the source impedance of the transducer connected should not exceed 10 kΩ for the ranges 0.05 up to and including 2 mV/cm.*
*If it does, the balancing time and the dead band is greater.*
*For the ranges 5 mV/cm and above, the source impedance does not influence the dynamic behaviour of the recorder.*

# IV. OPERATION

## A. SWITCHING ON THE MAINS VOLTAGE

Before the recorder is switched on, ensure that the "PEN" switch is in the "UP" position and the "ZERO-RECORD" switch is in the "ZERO" position.

The recorder is switched on by setting the "POWER" switch to the "ON" position.
The pilot lamp then lights (should it fail to do so, check the thermal fuse, fig. 8, item 3).

## B. FITTING THE CHART

To facilitate the correct positioning of the recording chart, two small lamps are incorporated behind small holes in the chart table. The recording paper is thus illuminated by two pin-points of light.
The chart must be laid on the chart table such that a horizontal line runs exactly over the two light points (see fig. 13). When this has been done, the "CHART HOLD" switch (see fig. 12) is set to the "ON" position. The paper is then drawn firmly against the plate by electrostatic action.
To remove the paper, the "CHART HOLD" switch is set to the "OFF" position.

*NOTE: When the recorder has been left unused for a long period, or has been used in a dusty or moisty room for a long time, paper hold-down will be weakened.*
*In this case, clean the chart table, using e.g. alcohol, and wipe with a dry cloth immediately.*

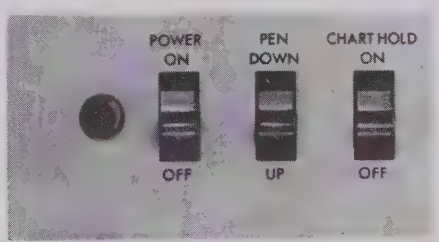



*Fig. 12*

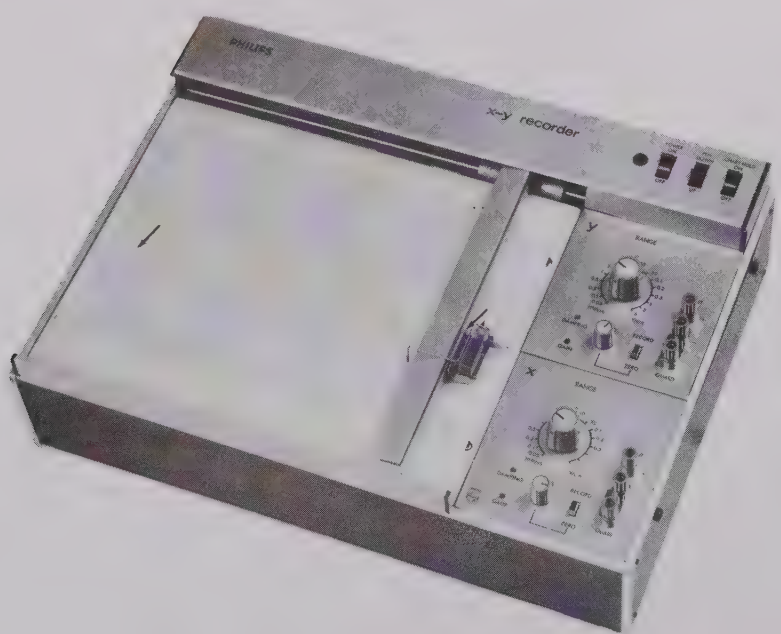



*Fig. 13*

## C. WRITING SYSTEM

1. Take a pen system, a nylon pen tip and an ink cartridge of the desired colour from the service kit.
– Slide the nylon pen tip on the capillary using the special tool (see fig. 14a).
– Slide the ink cartridge on the pen system, according to fig. 15. The seal of the cartridge is automatically broken when sliding it onto the pen system.
– Put the complete writing system into its holder (as indicated in fig. 16).
– Fit the bellows, delivered with the pen systems, to the orifice (fig. 15, item 1) and squeeze it until the pen tip gets moist.

**REMARK:** It is well possible that after two ink cartridges have been used the pen tip is worn sufficiently to thicken the recorded line.
Therefore, it is advisable to replace the pen tip after two ink cartridges have been used. To remove it, hold the capillary and slide the pen tip off with the aid of the special tool (see fig. 14b).

2. The pen is lowered onto the chart by setting the "PEN" switch to the "DOWN" position.
Alternatively, the pen can be lowered onto the chart by remote control. This is accomplished by leaving the "PEN" switch in the "UP" position and short-circuiting the two contacts of the "EXT. PEN LIFT" connector at the rear of the recorder (see fig. 8, item 2).
The pen is automatically lifted when the recorder is switched off.

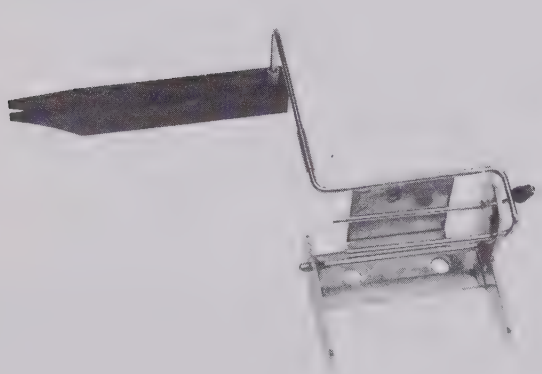


*Fig. 14a*

*Fig. 14b*

*Fig. 15*

*Fig. 16*

## D. ZERO POINT ADJUSTMENT

When the "ZERO-RECORD" switch is in the "ZERO" position, the circuit of the voltage source or transducer is interrupted and the input of the recorder short-circuited.
The zero point can be adjusted over the whole scale continuously by means of the "ZERO" potentiometer (fig. 7, item 2).
The X- and Y-axes can be drawn on the recording chart simply by setting the "ZERO-RECORD" switches to the "ZERO" position and turning the resp. "ZERO" potentiometers.
It is advisable to set the "ZERO-RECORD" swiches to the "ZERO" position when changing over the input connections of the recorder, in order to prevent the measuring systems making uncontrolled movements.

The "ZERO-RECORD" switch can also be used as a "standby" switch when the instrument is not recording, but is required for immediate use; no warming-up time is then needed.

## E. MEASURING RANGES

The recorder is equipped with 16 measuring ranges for both X- and Y-directions.
The range is adjusted by setting the "RANGE" selector switch to:

0.05–0.1–0.2–0.5–1–2–5–10–20 and 50 mV/cm
0.1–0.2–0.5–1–2 and 5 V/cm.

*NOTE: Both measuring ranges are protected against overload by means of a slip-coupling.*
*To minimise wear on the slip-couplings, ensure that the range selected is not too small.*
*The maximum voltage which may be applied to the input terminals is 200 V d.c. or 200 $V_{p\text{-}p}$.*

## F. ADJUSTMENT OF GAIN AND DAMPING

On the six most sensitive ranges of the input unit (0.05 through 2 mV/cm) the damping of the measuring system depends in principle on the source impedance of the transducer connected. Therefore, the gain and damping of the measuring system must be re-adjusted for these ranges every time a different source impedance is used. The adjustments are effected with the trimming potentiometers "DAMPING" and "GAIN" (fig. 7, item 3 and 4 resp.).
For the ranges from 5 mV/cm up, the source impedance does not affect the dynamic behaviour of the recorder.

1. Gain adjustment

a. For the ranges 0.05 up to and including 2 mV/cm:
– Set the "ZERO-RECORD" switch to the "ZERO" position (both systems).
– Connect a resistor, the value of which should be approx. the same as that of the source impedance to be connected, between the input terminals of both systems.
– Set the "ZERO-RECORD" switch of the X-system to "RECORD".
– Turn the "GAIN" potentiometer fully clockwise. This causes the measuring carriage of the X-system to oscillate.
– Turn the "GAIN" potentiometer counterclockwise until the oscillations stop.
– Set the "ZERO-RECORD" switch of the X-system to "ZERO" and the "ZERO-RECORD" switch of the Y-system to "RECORD".
– Turn the "GAIN" potentiometer of the Y-system fully clockwise. This causes the measuring carriage of the Y-system to oscillate.
– Turn the "GAIN" potentiometer counterclockwise until the oscillations stop.

b. For the ranges 5 mV/cm and above:
Follow the procedure described above, but omit to connect the resistors (i.e. input terminals open-circuit).

2. Damping adjustment

For the ranges 0.05 up to and including 2 mV/cm:
Fit a piece of chart paper and remove the voltage source, if connected.
Then, proceed as follows:

X-system:
– Adjust the gain as described above.
– Set the "ZERO-RECORD" switches of both X- and Y-systems to "ZERO".
– Connect a resistor, the value of which should be approx. the same as that of the source impedance to be connected, between the input terminals of the X-input unit.
– Conneft the terminal "–" to the "GUARD" terminal using the hinged strip.
– Set the "ZERO-RECORD" switch of the X-system to "RECORD".
– Quickly turn the "ZERO" potentiometer of the X-system for a deflection of approx. 15 cm. Measure the overshoot, which should be 2.5 mm. ( 1 % of f.s.d.). If not, adjust the "DAMPING" potentiometer and repeat the procedure until the correct overshoot is obtained.

To facilitate the measuring, the "ZERO" potentiometer of the Y-system can be moved.

Y-system:
– Adjust the gain as described above.
– Set the "ZERO-RECORD" switches of both X- and Y-systems to "ZERO".
– Connect a resistor, the value of which should be approx. the same as that of the source impedance to be connected, between the input terminals of the Y-input unit.
– Connect the terminal "–" to the "GUARD" terminal using the hinged strip.
– Set the "ZERO-RECORD" switch of the Y-system to "RECORD".
– Quickly turn the "ZERO" potentiometer of the Y-system for a deflection of approx.10 cm. Measure the overshoot, which should be 1.8 mm (1 % of f.s.d.). If not, adjust the "DAMPING" potentiometer and repeat the procedure until the correct overshoot is obtained.

To facilitate the measuring, the "ZERO" potentiometer of the X-system can be moved.

Check for correct damping as follows:

1. For the ranges 0.05 up to and including 2 mV/cm:
– Connect a resistor, the value of which should be approx. the same as that of the source impedance to be connected, to the input terminals of both the X- and the Y-input units.
– Connect the terminals "–" to the resp. "GUARD" terminals, using the hinged strips.
– Set both "ZERO-RECORD" switches to "ZERO".
– Connect a function generator, via a resistor of approx. 20 x the value of the source impedance to be connected, to the input terminals of both the X- and the Y-systems.
– Adjust the function generator to give a sinusoidal signal of 0.5 Hz and an amplitude, which causes a deflection of approx. 15 cm on the chart.
– Set the "ZERO-RECORD" switches of both systems to "RECORD".
One straight line without hysteresis gap should now be recorded. If not, repeat the damping adjustment procedure.

2. For the ranges from 5 mV/cm and above:
– Connect the terminals "–" to the resp. "GUARD" terminals, using the hinged strip.
– Set both "ZERO-RECORD" switches to "ZERO".
– Connect a function generator to the input terminals of both systems simultanuously and adjust it to give a sinusoidal signal of 0.5 Hz and an amplitude, which causes a deflection of approx. 15 cm on the chart.
– Set the "ZERO-RECORD" switches of both systems to "RECORD".
One straight line without hysteresis gap should now be recorded. If not, adjust the "DAMPING" potentiometers.

# V. MAINTENANCE

Every instrument, whether or not in continuous operation, requires maintenance from time to time. In normal use, the PM 8120 has an M.T.B.F. (Mean Time Between Failures) of approx. 2000 hours. This period, however, can be considerately extended if adequate attention is paid to maintenance.

## A. MECHANICAL PARTS

Maintenance at intervals of three months is sufficient when the instrument is not in continuous use. Where the instrument is in continuous use, however, maintenance should be carried out once a month. The following parts should be lightly lubricated, using the oil and the brush which are supplied in the service kit:

– guide pulleys of the drive cords
– bearing points of the drive cord levers (fig. 17, item 2)

Following parts should be cleaned before lubricating:

– guide shaft of the X-measuring carriage (fig. 17, item 1)
– slide of the Y-measuring carriage
– slide of the X-measuring carriage (fig. 17, item 3).

It is advisable to clean the guide shaft and slides regularly, in order to prevent unstable recording.

The drive cords and the gearwheels must not be lubricated.

*NOTE: Ensure that oil does not get between the slip-couplings of the motors.*

## B. CLEANING THE SURFACES

The housing can be cleaned, when necessary, with a damp cloth.
Wet ink stains on the chart table, or on the anodised, matt aluminum surfaces, can be removed with a wet cloth, the spot affected being rubbed with a dry cloth immediately afterwards.
Very persistent, dried ink stains on the chart table can be removed with, e.g. alcohol.

*NOTE: Do not try to remove ink stains on the anodised aluminum surfaces with alcohol, since this will damage the inscriptions.*

## C. ELECTRICAL MAINTENANCE

The instrument as supplied has been accurately calibrated in the factory before delivery. If, after a lengthy period, doubt should arise about the accuracy of the span of the measuring ranges, this can be checked against the specification by connecting a voltage source, the internal resistance and adjusted voltage of which are accurately known. A recommended voltage source is the Philips' PT 2248.
Both measuring systems can be calibrated as required with the aid of the resp. "CAL" potentiometers (fig. 4, item 3 and 4; for X and Y resp.).
It is safest, however, to entrust calibration to the Technical Service Dept. of the local Philips organisation.

*NOTE: The accuracy of the recording on the chart depends, among other things, on the temperature and relative humidity of the surroundings.*
*In calibrating, use should be made of, say, an accurate rule.*

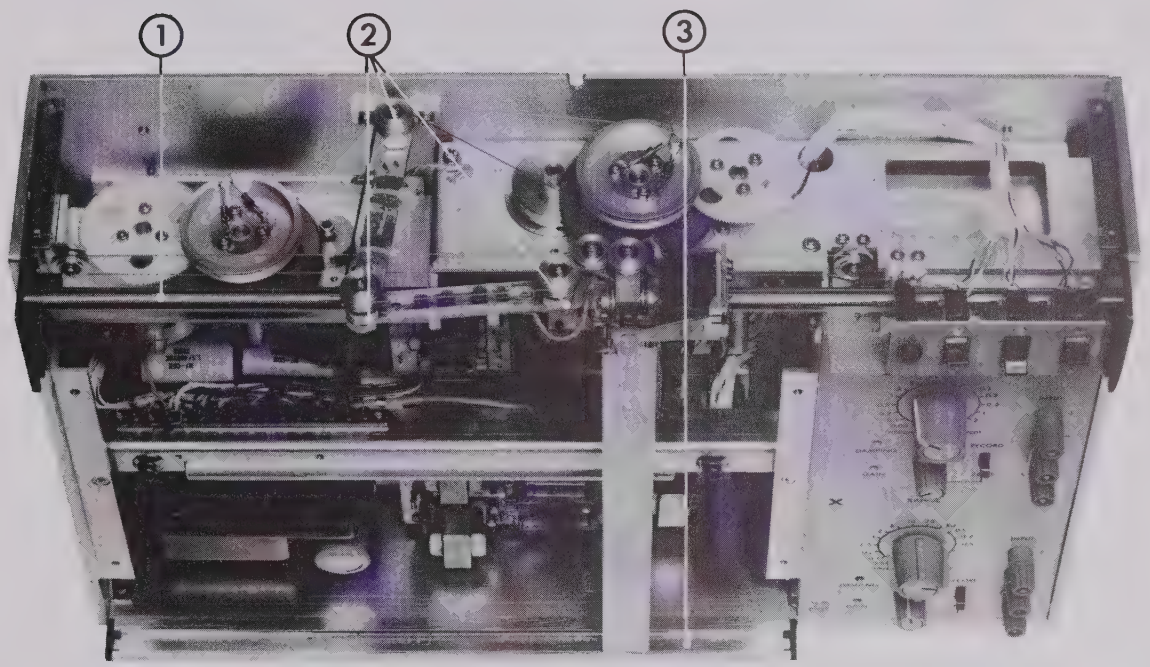



*Fig. 17*

## VI. PRINCIPLE OF OPERATION

The measuring system comprises two servo-systems, each of which forms an automatic compensator.
One servo-system is for the X-system (horizontal deflection), the other for the Y-system (vertical deflection).
The servo-system operates as follows (see fig. 18):
The compensation circuit incorporating the measuring potentiometer $R_m$ is fed at points C and D with a direct current of precisely known value. A voltage $E_C$ of known value thus arises between points A and B; this voltage is in series with the unknown voltage $E_X$ and is of opposite polarity.
The voltage difference $E_C$ - $E_X$ is converted into an a.c. voltage by the chopper T, amplified by amplifier V and fed to the servo-motor M.
The driving signal actuates the servo-motor, and the slider of the measuring potentiometer, which is mechanically coupled with the servo-motor, is shifted in a direction which reduces the difference voltage to zero. Thus the position of the slider is a measure of the value of the unknown voltage $E_X$.

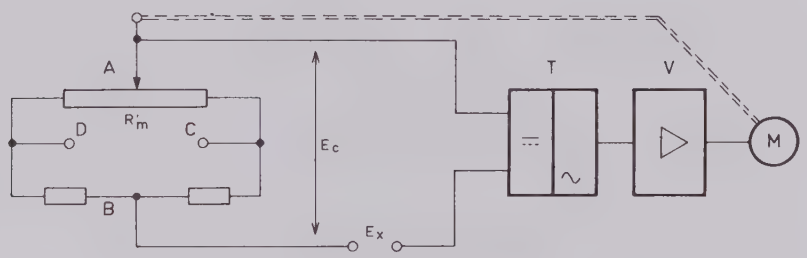



*Fig. 18*

MA 5197

**Explanation of the block diagram**

Fig. 43 shows the block diagram for the X-system only. The Y-system is identical.
Fig. 44 represents the basic diagram.
The servo-system consists essentially of three sections: the input unit with input attenuator, damping network, chopper and pre-amplifier; the power unit with driving amplifier, output amplifier and the various supply transformers; and the servo-motor, which is mechanically coupled with the measuring potentiometer.
The input circuit comprises the transducers, input terminals and measuring range.
The zero point is adjusted with the "ZERO" potentiometer.
The input sensitivity is adjusted with the "RANGE" switch. In the six most sensitive positions of the measuring range switch, the complete unit operates as a semi-direct compensator, with a resistance of 1 MΩ across the input terminals. In the other ten positions the signal is first attenuated by a voltage divider. Here, the instrument has a constant input impedance of 1 MΩ.
The amplifier comprises a number of sections.
The input is a double-T hum filter for 50 and 100 Hz, which is easily switched over for 60 and 120 Hz. This filter ensures that possible interference signals, superimposed on the measuring signal, are reduced to a specific maximum value (see VII, TECHNICAL DATA).
The (d.c.) input signal is then converted into an a.c. voltage by a chopper, this signal being fed to the pre-amplifier (unit A), via the input transformer.
The bridge supply unit (A4) is also incorporated on this printed wiring board.
The dynamic behaviour of the recorder is adjusted by means of the "GAIN" and "DAMPING" potentiometers. The damping adjustment is effected by a differentiating network in the feedback circuit of the system.
The input unit can be calibrated, if required, with the "CAL" potentiometer.
The input unit is isolated with respect to earth. The earth connection of the input unit is connected via a capacitor to the instrument earth and serves as measuring earth ("GUARD").

### Power unit

The signal is fed from the "GAIN" potentiometer in the input unit to the driver amplifier, which, in turn, drives the output amplifier.
The driver amplifiers, for both channels are mounted on the same printed wiring board unit D, there being a common power unit.
The supply transformer T1 of the instrument is also located in the power unit.
Transformer T2 is separate for the two channels and powers the respective measuring bridges.
The output stage drives the servo-motor, which is mechanically coupled with the measuring potentiometer, the system thus being intercoupled.

### Joint section

The electrical pen-lift system is supplied from the power unit. This system can be operated either from the front panel, or by means of an external switch.
The pen is automatically raised when the instrument is switched off.
The centering lamps and the electrostatic paper hold-down system are powered from a separate transformer (T3), which is connected to a fixed tapping on the primary winding of the supply transformer T1.
The paper is secured as follows:
The plate on which the paper rests consists of two insulating layers, separated by conductive lamina, which are connected alternately to +600 and −600 V. The electrostatic lines of force run through, and so attract, the paper.

## VII. TECHNICAL DATA

| | |
|---|---|
| Measuring system | Null-balance potentiometric system with all solid state amplifier. |
| Measuring ranges | Both X- and Y-axis equipped with a multi-range unit, viz.: 0.05–0.1–0.2–0.5–1–2 mV/cm. (potentiometric input) 5–10–20–50 mV/cm and 0.1–0.2–0.5–1–2–5 V/cm (attenuator input). |
| Accuracy | 0.25 % of f.s.d. |
| Reproducibility | 0.1 % of f.s.d. |
| Zero adjustment | Zero point continuously adjustable through-out the whole recording range (0 - 100 %). |
| Zero-Record controls | Each input unit comprises a "ZERO-RECORD" switch, which enables quick zero-check and easy drawing in of coordinate axes.<br>These switches can also be used as a **"standby"** control when changing over the input connections. |
| Measuring bridge supply | Zener diode regulated, compensated for ambient temperature variations.<br>Stability: ±0.005 %/°C. |
| Writing speed | 300 mm/s. max. |
| Frequency response | 0.5 Hz with hysteresis gap within accuracy limit. |
| Chart | Any desired type of paper can be used, up to DIN A4 format (8 ½" x 11"), e.g. transparant, preprinted etc.<br>X-axis: 250 mm<br>Y-axis: 180 mm<br>The instrument is equipped with an electrostatic chart hold-down system, which can be controlled by the flick of a switch.<br>Two pin-point lights, shining through the paper, allow quick aligment of the chart with respect to the X- and Y-axes of the instrument. |
| Source impedance | Ranges 0.05 through 2 mV/cm: up to 10 kΩ.<br>From 5 mV/cm and above: no restriction with respect to dynamic behaviour.<br>*NOTE: Using higher source impedance than permitted causes increase in dynamic error when measuring fast changing phenomena.* |
| Input impedance | 0.05 – 2 mV/cm : > 100 kΩ (off balance)<br>1 MΩ at null<br>5 mV/cm – 5 V/cm : 1 MΩ |
| Stray voltage rejection | AC-S.M.R.R.: 80 dB<br>AC-C.M.R.R.: 150 dB, to a maximum of 125 V r.m.s.<br>For 50 and 100, resp. 60 and 120 Hz.<br>DC-C.M.R.R.: 150 dB |
| Overload voltage | 200 V d.c. or 200 $V_{p-p}$ between input terminals. |
| Isolation resistance | > 5000 MΩ between input terminals and earth. |

| | |
|---|---|
| Gain and damping controls | Separate adjustment of gain and damping gives versatility of application. |
| Writing system | Nylon-fiber pen tip, disposable ink cartridge.<br>Two complete pen systems for use with different colours are supplied as standard. |
| Pen lift | Pen lift is electrically controlled: local or remote.<br>Pen is automatically lifted when mains is switched off. |
| Ambient temperature range | 20 ±20 °C. |
| Mains supply voltage | 100, 117, 217, or 234 V ±10 %<br>50 or 60 Hz ±5 % |
| Dimensions | Height: 11.9 cm (excl. rubber stands)<br>Width : 43.5 cm<br>Depth : 31.2 cm |
| Weight | 12 kg (27 lbs.) approx. |

## VIII. FAULT FINDING

Should the instrument become defective in any way, the user can obtain all necessary assistance from Philips Technical Service Department, which maintains a widespread organisation in most countries. If you wish to repair the instrument yourself refer to the part "SERVICE INFORMATION" in this manual.
Certain failures, however, can be cured very easily and, in order to save time and money, it is advisable to check the following fault finding list before notifying the Technical Service Dept.

If the instrument does not function at all, first check that the mains voltage is present. If it is, set the "ZERO-RECORD" switches to the "ZERO" positions and check the following list.

| FAULT | POSSIBLE CAUSE | CURE |
|---|---|---|
| Instrument does not work and POWER ON lamp does not glow | Fuse FS 101 at the rear of the instrument;<br>mains lead | Check fuse and replace if necessary.<br>Check mains lead and repair or replace if necessary. |
| POWER ON lamp is on one channel does not function properly | Chopper of relevant input unit | Replace chopper; interchange with chopper of other channel to make sure it is the cause of the failure. If not, interchange input units to locate the trouble. |
| Unstable recording | Sliders of measuring carriage dirty;<br>choppers | Clean sliders (see V, Maintenance)<br>Replace choppers if necessary. |
| Weak chart hold-down | Chart table dirty | Clean chart table with wet cloth, or alcohol, wipe with dry cloth afterwards. |
| Irregular writing | Ink cartridge empty<br>Chart not flat | Replace ink cartridge<br>Refit chart |

# IX. INPUT UNITS

This chapter contains information to assist in checking the input units, and a service parts list.

## A. DESCRIPTION

The input units of both the X- and Y-systems are similar and incorporate:

1. Range selector network
2. Damping and calibration network
3. Hum filter (unit H)
4. Chopper and input transformer
5. Pre-amplifier (unit A)
6. Measuring bridge supply

## B. GENERAL FAULT FINDING

If the fault is suspected to be in the amplifier section of the recorder, the following procedure can be used to determine in which part the fault is likely to be.

1. If both channels do not function properly, the fault is probably in the power amplifier section. For further information, refer to Ch. X AMPLIFIER.
2. If one of the channels does not function properly, interchange the input units. This determines whether the fault is in the input unit or in the amplifier.
   If the latter case, refer to Ch. X AMPLIFIER.
3. If the fault has been located as being in the input unit, first check the chopper of the relevant unit, by interchanging it with the one from the other input unit. If the fault is not in the chopper, it is likely to be in the pre-amplifier or in the measuring bridge supply. In this case, follow the procedures given under C and D.

## C. PRE-AMPLIFIER (unit A)

To gain access to the pre-amplifier printed wiring board, the following steps should be taken:
– Remove the input units (see Ch. III-A)
– Remove the cover plates (fig. 19, items b and d) by loosening the screws items a and c.
Loosen the rear plate (fig. 20, item a) by removing the screws, items b and c.
The printed wiring board of unit A is accessible (see fig. 21) when the rear plate is bent back.
– Reconnect the input unit with the recorder and measure the following voltages:

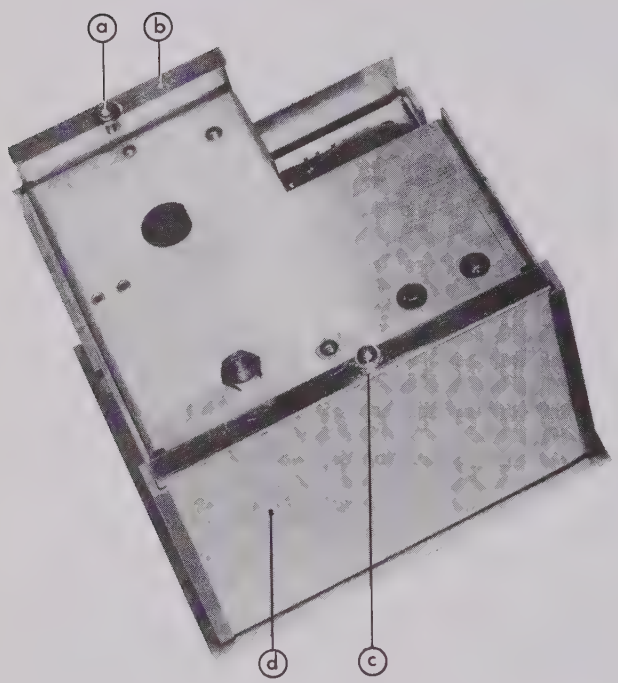



*Fig. 19*

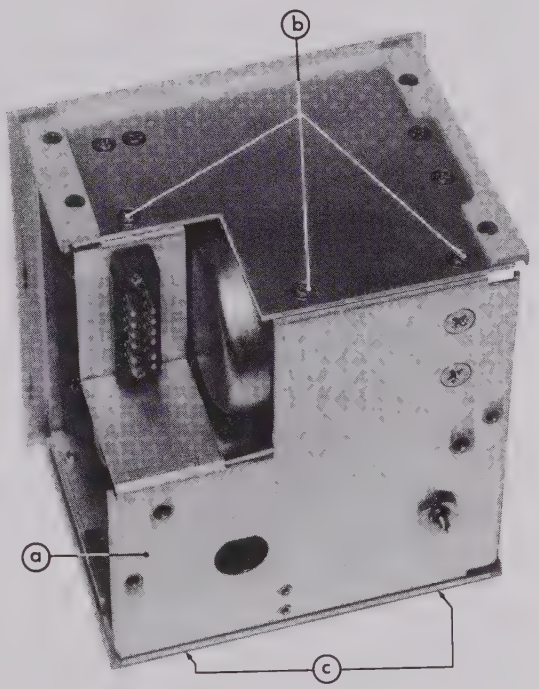



*Fig. 20*

### 1. Supply voltages

Measure the following supply voltages of unit A with a universal voltmeter.

| Meter connection | Voltage |
|---|---|
| between points 6 and 7 | 12 V a.c. |
| across C416 | 15 V d.c. |
| across C414 | 8.5 V d.c. |
| $V_{ce}$ of TR405 | 6.4 V d.c. |
| across GR105 | 8.5 V d.c. |
| across C406 | 6.5 V d.c. |

Measure the voltage between points 5 and 12 of connector J102.
This voltage (supply voltage of chopper) should be 6.3 V a.c.

Measure the ripple voltage on:

| | |
|---|---|
| C414 | $\leqslant 2\ mV_{p\text{-}p}$ |
| C406 | $\leqslant 2\ mV_{p\text{-}p}$ |

**2. Collector-emitter voltages**

Measure the following voltages with the aid of a universal voltmeter:

| Transistor | $V_{ce}$ (V d.c.) |
|---|---|
| TR401 | 4.5 |
| TR402 | 1.8 |
| TR403 | 5.2 |
| TR404 | 4.5 |

**3. Emitter currents**

Measure the following voltages across the emitter resistors with a valve voltmeter.

| Transistor | Measure across | V d.c. |
|---|---|---|
| TR401 | R429 ( 1.5 kΩ) | 0.5 |
| TR402 | R431 (100 Ω) | 0.01 |
| TR403 | R437 ( 1.5 kΩ) | 1.3 |
| TR404 | R440 (100 Ω) | 0.2 |

**4. Amplification**

Set the "ZERO-RECORD" switch to the "ZERO" position.
Set the "RANGE" switch to the most sensitive position (0.05 mV/cm).
Turn "GAIN" potentiometer fully counterclockwise.
Now shift the pen manually for a deflection of 1 cm, which is equivalent to an input signal of 50 $\mu$V.
Measure the a.c. voltage between points 1 and 3 of R446. This voltage should be at least 200 $mV_{p-p}$.

**5. Interference signals**

Set the "ZERO-RECORD" switch to the "ZERO" position.
Adjust "GAIN" potentiometer for optimum reproducibility (see Ch. IV-F).
The a.c. voltage, measured between terminals 1 and 3 of R446 should be less than 25 $mV_{p-p}$.

## D. MEASURING BRIDGE SUPPLY

The supply for the measuring bridge is located on the printed wiring board of unit A. It comprises (see principal diagram, fig. 44):
GR101 (2 diode MB 302)
C404 (electrolytic capacitor, 47 $\mu$F)
R426 and R427 (resistors, 1 kΩ)
GR102 (zener diode, ZR 220)
GR103 (zener diode, 1S 551)

Measure the following voltages with a valve voltmeter:

| Meter connection | Voltage |
|---|---|
| between points 8 and 10 of unit A | 30 V a.c. |
| between points 9 and 10 of unit A | 30 V a.c. |
| across C404 | 40 V d.c. |
| across GR102 | 19 V d.c. |
| between points 11 and 12 of unit A | 8.5 V d.c. |

## E. ACCURACY CHECK

*NOTE: Before making an accuracy check, ensure that both the X- and Y-systems are calibrated, as described in Chapter V-C.*

To check the accuracy of the recorder, a precisely known d.c. voltage is applied to the instrument. This voltage causes a deflection on the chart, which can be measured with, for instance, an accurate rule.
As the input voltage level, corresponding to the required deflection, depends on the position of the "RANGE" switch, ten specific ranges, together with the input voltage to be applied, are stated in Table I.
The deflection on the chart should be:

X-system: 200 ± 0.625 mm ( ±0.25 % of f.s.d.)
Y-system: 150 ± 0.45 mm (±0.25 % of f.s.d.)

To perform the check proceed as follows:

### 1. X-system

- Set the "RANGE" switch to 0.05 mV/cm.
- Set the "ZERO-RECORD" switches of both the X- and Y-systems to "ZERO".
- Set the measuring carriage of the X-system to the left-hand end of the scale and the Y-measuring carriage to the lower end of the scale, by means of the "ZERO" potentiometers.
- Connect the voltage source to the input terminals of the X-input unit and adjust it to the correct value, as stated in Table I.
- Set the "ZERO-RECORD" switch (X-system) to "RECORD".
- Measure the deflection. This should be 200 ± 0.625 mm.
- Set switch "ZERO-RECORD" to "ZERO".
- Proceed in the same way for the other nine positions of the "RANGE" switch, moving the Y-measuring carriage about 15 mm. after each step.

### 2. Y-system

Use the same method for checking the Y-system.
The deflection should now be 150 ± 0.45 mm.

**Table I**

| RANGE | $V_i$ (X) | $V_i$ (Y) |
|---|---|---|
| 0.05 mV/cm | 1 mV | 0.75 mV |
| 0.1 mV/cm | 2 mV | 1.5 mV |
| 0.2 mV/cm | 4 mV | 3 mV |
| 0.5 mV/cm | 10 mV | 7.5 mV |
| 1 mV/cm | 20 mV | 15 mV |
| 2 mV/cm | 40 mV | 30 mV |
| 10 mV/cm | 200 mV | 150 mV |
| 0.2 V/cm | 4 V | 3 V |
| 1 V/cm | 20 V | 15 V |
| 5 V/cm | 100 V | 75 V |

If a constant error is found in the first six positions of the "RANGE" switch, readjust the "CAL" potentiometer of the relevant input unit.
If the error is in one or more of the first six ranges, check the value of the resistors R410 through R415.
If an error is found in one or more of the other positions of the "RANGE" switch, check the value of the resistors R401 through R405.

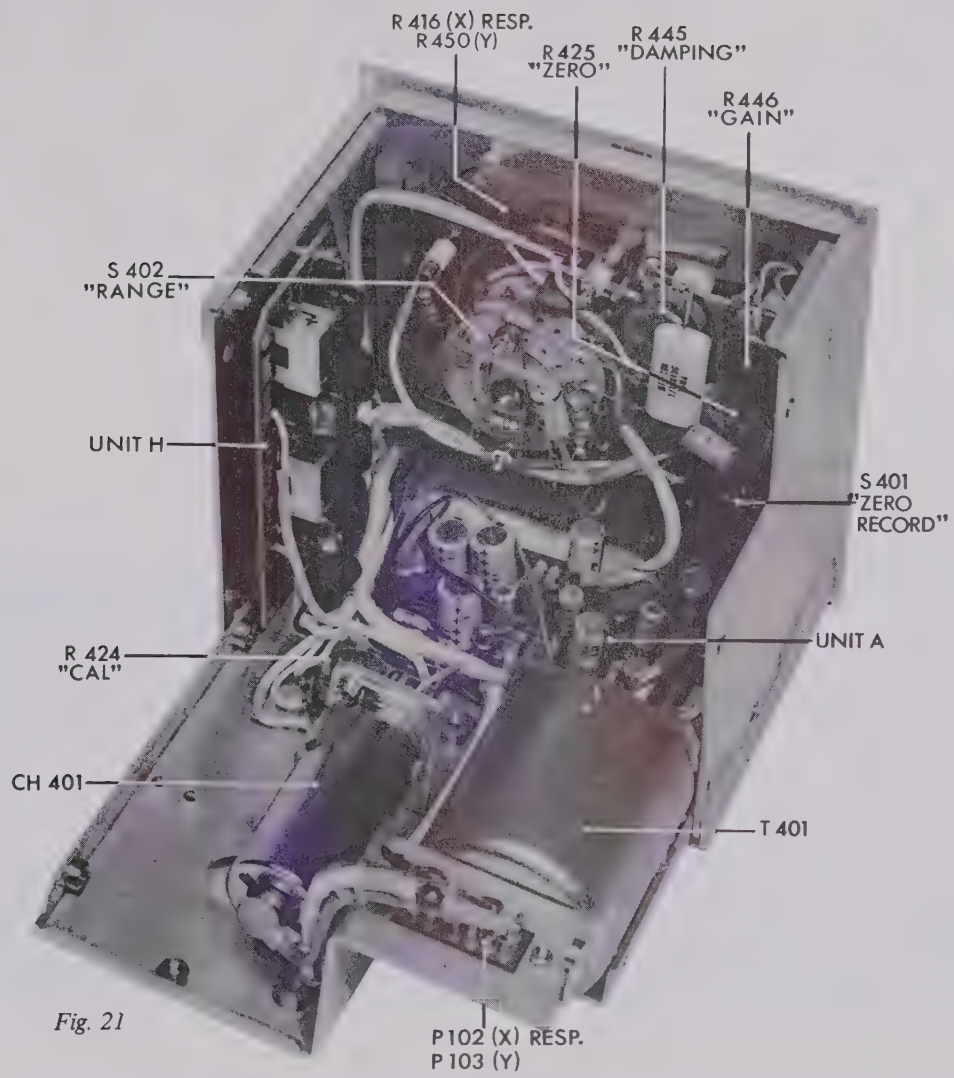



*Fig. 21*

## F. REPLACEMENT OF PARTS

### 1. Pre-amplifier unit

To remove the pre-amplifier printed wiring board, first perform the procedure as described in part C of this chapter; then:
– Loosen the four fixing screws of the printed wiring board
– Unsolder the wiring.

To remount the pre-amplifier printed wiring board:
– Connect the wiring according to undermentioned table
– Fasten the four fixing screws.

| Cable-form | Colour of wire | Connect to |
|---|---|---|
| White, red mark | red | point 1 |
| | white | point 2 |
| | black | point 3 |
| Loose wiring | black | point 4 |
| | red | point 5 |
| | orange | point 6 |
| | violet | point 7 |
| White | red | point 8 |
| | blue | point 9 |
| | white | point 10 |
| Loose wiring | white/blue | point 11 |
| | white/violet | point 12 |
| White, yellow mark | neutral | point 11 |
| | red | point 12 |
| Loose wiring | grey | point 13 |
| | blue | point 15 |

**2. Replacement of the input transformer**

When replacing the input transformer, connect the wiring as follows:

| Cable-form | Colour of wire | Connect to |
|---|---|---|
| White, blue mark | red | point 1 of chopper CH401 |
| | white | point 6 of CH401 |
| Loose wiring | black | point 5 of CH401 |
| | white/blue | master contact of first segment of "RANGE" switch S402 |

## LIST OF SERVICE PARTS

| Fig. | Item | Description | Service code number |
|---|---|---|---|
| 22 | | Unit A, complete | 4822 216 90404 |
| 23 | | Unit H, complete | 4822 216 90403 |
| **Parts of unit A:** | | | |
| 22 | TR401 | FET-transistor, 2SK15-0 | 4822 130 40767 |
| 22 | TR402–TR405 | Transistor, 2SC539S | 4822 130 40768 |
| 22 | CD101 | Diode, MB 302 | 4822 130 30675 |
| 22 | CD102 | Zener diode, ZR220 | 4822 130 30677 |
| 22 | CD103 | Zener diode, 1S551 | 4822 130 30681 |
| 22 | CD104 | Rectifier, MB401 | 4822 130 30676 |
| 22 | CD105 | Zener diode, 1S334 | 4822 130 30679 |

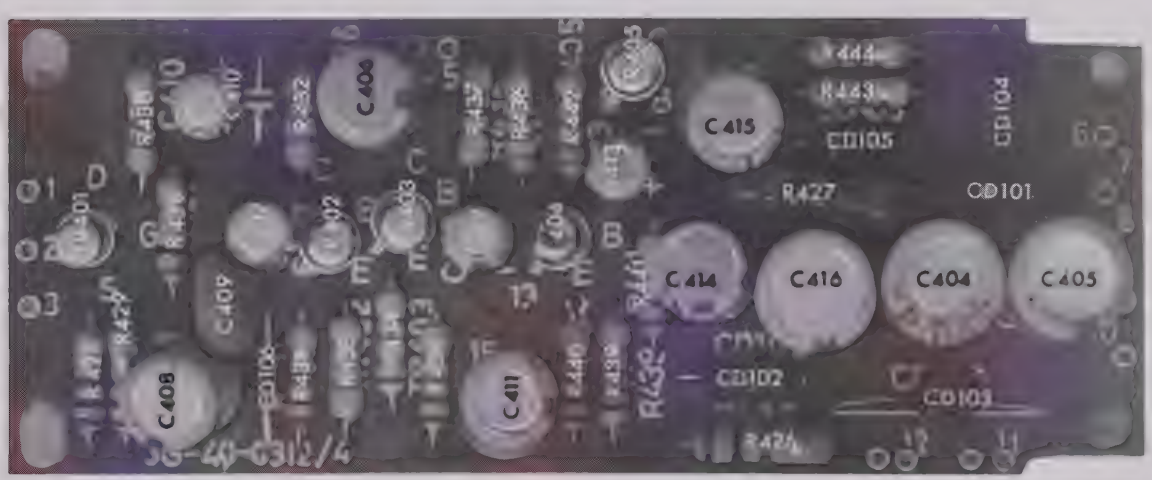



*Fig. 22*

*Fig. 23*

**Other parts:**

| | | | |
|---|---|---|---|
| 44 | R401 | Metal-film resistor, 990 k, 0.1 % | 4822 116 50279 |
| 44 | R402 | Metal-film resistor, 9 k, 0.1 % | 4822 116 50943 |
| 44 | R403 | Metal-film resistor, 900 Ω, 0.1 % | 4822 116 50942 |
| 44 | R404 | Metal-film resistor, 90 Ω, 0.1 % | 4822 116 50944 |
| 44 | R405 | Wire-wound resistor, 10 Ω, 0.1 % | 4822 113 10176 |
| 44 | R410, 111 | Metal-film resistor, 100 Ω, 0.1 % | 4822 116 50268 |
| 44 | R412 | Metal-film resistor, 200 Ω, 0.1 % | 4822 116 50267 |
| 44 | R413 | Metal-film resistor, 600 Ω, 0.1 % | 4822 116 50266 |
| 44 | R414 | Metal-film resistor, 1 k, 0.1 % | 4822 116 50274 |
| 44 | R415 | Metal-film resistor, 2 k, 0.1 % | 4822 116 50941 |
| 4 | 2 | Screw | 4822 502 11201 |
| 4 | 3 | Isolation bush for screw | 4822 532 60536 |
| 21 | R416 | Metal-film resistor, 587 k, 1 % (X) | 4822 116 50252 |
| 21 | R450 | Metal-film resistor, 808 k, 1 % (Y) | 4822 116 51076 |
| 21 | R424 | Potentiometer ("CAL"), 200 k | 4822 101 20423 |
| 21 | R425 | Potentiometer ("ZERO"), 5 k | 4822 101 20397 |
| 21 | R445 | Potentiometer ("DAMPING"), 5 k | 4822 101 20396 |
| 21 | R446 | Potentiometer ("GAIN"), 10 k | 4822 101 20395 |
| 21 | S401 | Switch, "ZERO-RECORD" | 4822 277 20117 |
| 21 | S402 | Switch, "RANGE" | 4822 273 50122 |
| 21 | CH401 | Chopper | 4822 280 10053 |
| 21 | T401 | Input transformer | 4822 142 50122 |
| 21 | P102, 103 | Plug (on chassis, male) | 4822 265 40109 |
| | J102, 103 | Plug (female) | 4822 266 40052 |
| 24 | 1 | Front panel, X-system | 4822 455 90393 |
| 24 | 1 | Front panel, Y-system | 4822 455 90394 |
| 24 | 2 | Knob, for "RANGE" switch | 4822 413 40112 |
| 24 | 3 | Cap for knob | 4822 413 70037 |
| 24 | 4 | Terminal, "+", "–", "GUARD" | 4822 290 40011 |
| 24 | 5 | Hinged strip | 4822 290 30001 |
| 24 | 6 | Knob, for "ZERO" potentiometer | 4822 413 30082 |
| 24 | 7 | Cap for knob | 4822 413 70038 |

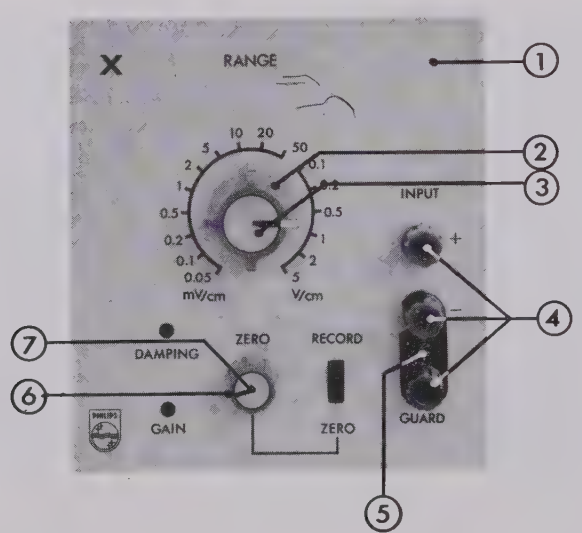



*Fig. 24*

# X. AMPLIFIER

This chapter contains information to assist in checking the amplifier section of the recorder, and a service parts list.

## A. DESCRIPTION

The amplifiers for the X- and Y-systems are identical and have been split up into two parts, viz.:
1. Pre-amplifiers, which are located in the input units (see Ch. IX-C)
2. Power amplifiers, built together in one power unit

The power unit also delivers the supply voltages for the input units.
It has been built as a sub-chassis which can be easily removed from the recorder.
The driver stages for the X- as well as the Y-output amplifiers are situated on the same printed wiring board (unit D).
For further information refer to Ch. VI. PRINCIPLE OF OPERATION and to the basic diagram (fig. 44).

## B. GENERAL FAULT FINDING

If the fault has been located as being in the amplifier section of the recorder, the following procedure can be used to determine if the fault is in the power amplifier or in the pre-amplifier.

1. If only one of the channels shows a malfunction, the fault is likely to be in the input unit. Interchange the input units to make sure. If it is in the input unit, refer to chapter IX for further information.
2. If both channels show a malfunction, the fault is likely to be in the power amplifier or in the supply of the power unit. In this case, follow the procedures given below.

## C. POWER UNIT

### a. Dismounting

Remove the power unit from the recorder as follows:
– Remove the writing system.
– Remove the chart table by loosening the four screws (fig. 25, item a).
– Remove the five fixing screws (fig. 26, item a), while supporting the power unit.
– Disconnect the plug (fig. 27, item c).

To remove the printed wiring board (unit D):
– Loosen the four screws (fig. 27, item a) and fold the printed board backwards.
– Unsolder the wiring.

### b. Checking the amplifier

Reconnect the power unit with the recorder.
Turn the "GAIN" potentiometers fully counterclockwise.
Measure the following voltages using a valve voltmeter:

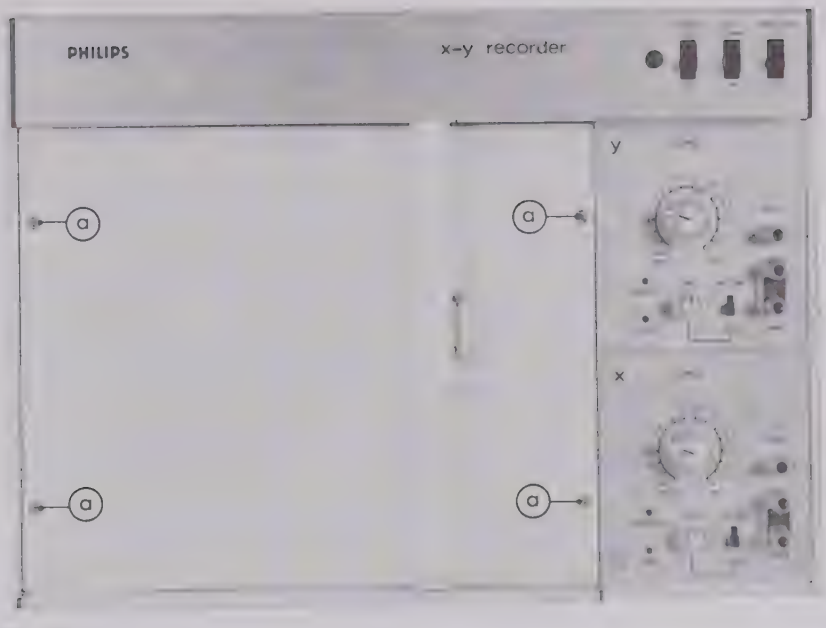



*Fig. 25*

*Fig. 26*

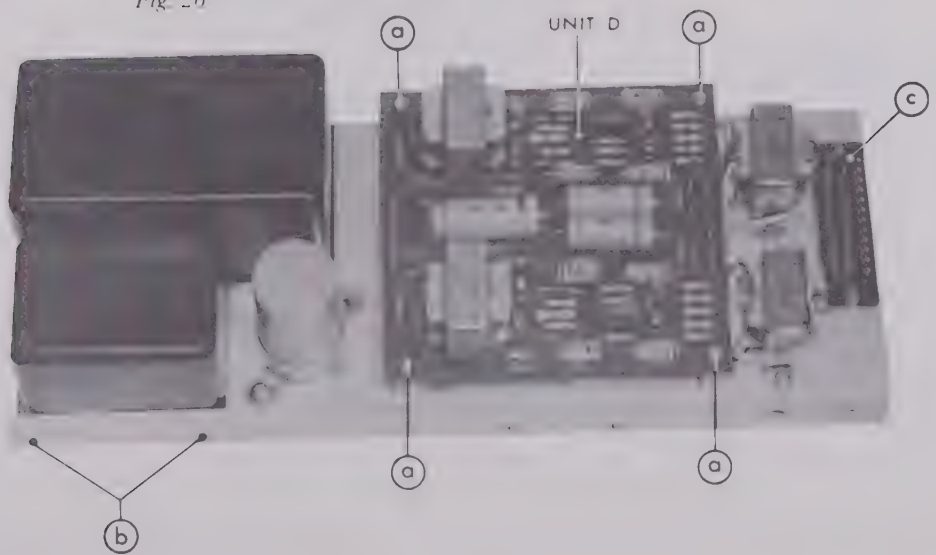



*Fig. 27*

**1. Supply voltages**

| Meter connection | | Voltage |
|---|---|---|
| Between points 1 and 23 of plug J101 | | 100 V a.c. |
| Across secundary of transformer T206 | | 10 V a.c. |
| Between points 11 and 12 of unit D | | 18 V a.c. |
| Across C220 | | 13 V d.c. |
| Across C218 | | 24 V d.c. |
| Across C217 | for X-channel | 12 V d.c. |
| Across GR215 | for X-channel | 6 V d.c. |
| Across C219 | for Y-channel | 12 V d.c. |
| Across GR214 | for Y-channel | 6 V d.c. |

**2. Collector-emitter voltages**

| Transistor | | $V_{ce}$ (V d.c.) |
|---|---|---|
| TR212 | | 13 |
| TR211 | | 13 |
| TR207 | X-channel | 7.5 |
| TR208 | X-channel | 7.5 |
| TR205 | X-channel | 2.0 |
| TR206 | X-channel | 2.0 |
| TR209 | | 13 |
| TR210 | | 13 |
| TR203 | Y-channel | 7.5 |
| TR204 | Y-channel | 7.5 |
| TR202 | Y-channel | 2.0 |
| TR201 | Y-channel | 2.0 |

**3. Emitter currents**

| Transistor | Measure across | | | $V_{Re}$ (V d.c.) |
|---|---|---|---|---|
| TR201 | R204 | ( 47 Ω) | | 5.5 |
| TR202 | R205 | ( 47 Ω) | | 5.5 |
| TR203 TR204 | R213 | (330 Ω) | Y-CHANNEL | 5.2 |
| TR209 TR210 | R235 | ( 1 Ω) | | 0.1 |
| TR205 | R222 | ( 47 Ω) | | 5.5 |
| TR206 | R223 | ( 47 Ω) | | 5.5 |
| TR207 TR208 | R231 | (330 Ω) | X-CHANNEL | 5.2 |
| TR211 TR212 | R236 | ( 1 Ω) | | 0.1 |

### 4. Ripple voltages

| Measure at | $V_{p\text{-}p}$ |
|---|---|
| C220 | $\leqslant 1.0$ V |
| C218 | $\leqslant 1.5$ V |
| C217 | $\leqslant 5$ mV |
| C219 | $\leqslant 5$ mV |
| GR215 | $\leqslant 2$ mV |
| GR214 | $\leqslant 2$ mV |

### 5. Amplification

Disconnect points 1 and 2 (X-channel) or 3 and 4 (Y-channel) of unit D and connect these points to a generator, which is adjusted to give a frequency of 50 Hz and an amplitude of 5 $mV_{p\text{-}p}$.
Measure the voltage across plug J101 points 14 and 25 (X-channel) or 15 and 26 (Y-channel).
The measured voltage should be at least 5 $V_{p\text{-}p}$.

### 6. Interference signals

Turn "GAIN" potentiometers fully counterclockwise.
Measure the voltage across plug J101 points 14 and 25 (X-channel) and between 15 and 26 (Y-channel).
The measured voltage should be less than 2 $V_{p\text{-}p}$.

## D. REPLACEMENT OF PARTS

The power and the reference transformers (T206 and T205 resp.) are delivered complete with cable-forms. These transformers are mounted on a separate sub-chassis which can be removed from the power unit by loosening the screws, fig. 27, item b and fig, 28, item a.

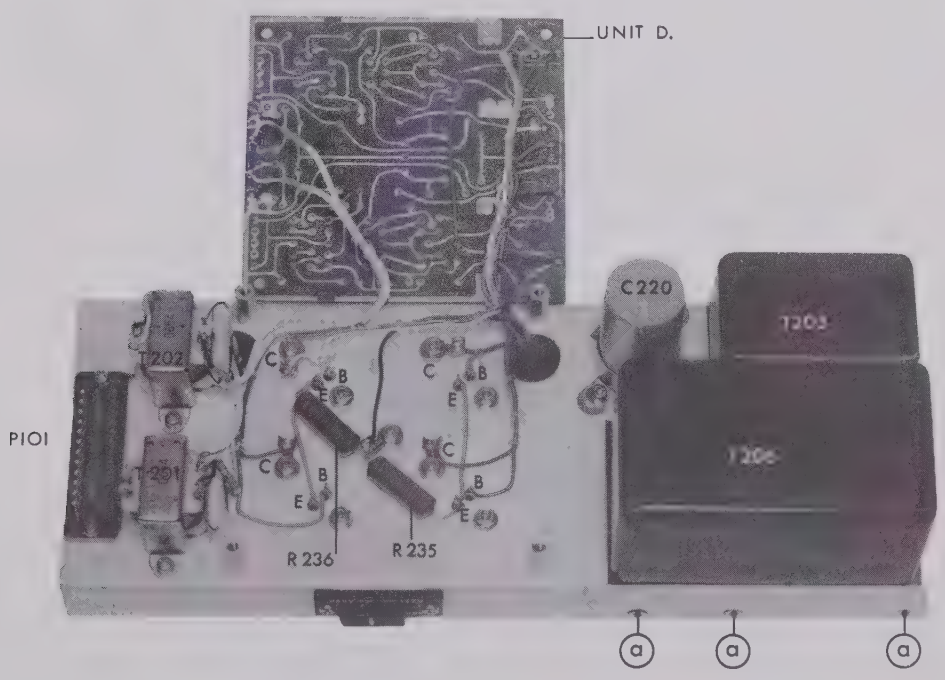



*Fig. 28*

The transformers can then be removed from the sub-chassis by unsoldering the relevant cable-forms and loosening the screws, fig. 29, items a and b.
When remounting the transformers, connect the cable-forms according to table II.
When remounting the printed wiring board (unit D), connect the wiring according to table III.

*Fig. 29*

**Table II: Connection of cable-forms**

| Transformer | Cable-form | Colour of wire | Connection point |
|---|---|---|---|
| T206 | | brown | point 1 of J202 |
| | | red | point 2 of J202 |
| | | orange | point 3 of J202 |
| | | yellow | point 4 of J202 |
| | | green | point 5 of J202 |
| | | blue | point 6 of J202 |
| | | grey | points 11 and 12 of unit D |
| | | violet | CD216 |
| | | black | R235, R236 |
| T205 | Red | red | point 33 of P101 |
| | | blue | point 32 of P101 |
| | | white | point 21 of P101 |
| | | black | point 4 of TB201 |
| | Blue | red | point 28 of P101 |
| | | blue | point 29 of P101 |
| | | white | point 6 of P101 |
| | | black | point 2 of TB201 |
| | Yellow | red | point 7 of P101 |
| | | blue | point 8 of P101 |
| | | white | point 18 of P101 |
| | | black | point 2 of TB201 |

| Transformer | Cable-form | Colour of wire | Connection point |
|---|---|---|---|
| T205 | White (four wires) | red | point 11 of P101 |
| | | blue | point 12 of P101 |
| | | white | point 20 of P101 |
| | | black | point 4 of TB201 |
| | White (three wires) | red | point 23 of P101 |
| | | white | point 1 of P101 |
| | | black | point 13 of P101 |

**Table III**

| Unit D point | Colour of wire | Connected to |
|---|---|---|
| 1 | white | point 3 of T202 |
| 2 | black | point 4 of T202 |
| 3 | white | point 3 of T201 |
| 4 | black | point 4 of T201 |
| 5 | violet | e-TR211 |
| 6 | brown | b-TR212 |
| 7 | white | b-TR211 |
| 8 | black | negative terminal of GR216 |
| 9 | green | c-TR212 |
| 10 | N.C. | – |
| 11 | grey | T206 |
| 12 | grey | T206 |
| 13 | orange | c-TR209 |
| 15 | grey | b-TR210 |
| 16 | yellow | b-TR209 |
| 17 | blue | c-TR210 |
| B2 | red | positive terminal of GR216 |

## LIST OF SERVICE PARTS

| Fig. | Item | Description | Service code number |
|---|---|---|---|
| 27 | Unit D | Unit D, complete | 4822 216 90405 |
| **Parts of unit D:** | | | |
| 30 | TR201-208 | Transistor, 2SC538A | 4822 130 40766 |
| 30 | CD201-204, 206, 208-211, 213 | Diode, 10D1 | 4822 130 30169 |
| 30 | CD205, 212 | Diode, MA26 | 4822 130 30674 |
| 30 | CD207 | Rectifier, MB401 | 4822 130 30676 |
| 30 | CD214, 215 | Zener diode, 1S331 | 4822 130 30678 |
| 30 | CD216 | Rectifier, 5B05 | 4822 130 30682 |
| 30 | T203, 204 | Driver transformer | 4822 142 40233 |
| **Other parts of the power unit:** | | | |
| 28 | T201, 202 | Isolating transformer | 4822 142 40234 |
| 28 | T205 | Reference transformer | 4822 148 20085 |
| 28 | T206 | Power transformer | 4822 146 20448 |
| 28 | P101 | Plug (on chassis, male) | 4822 265 60039 |
| – | J101 | Plug (female) | 4822 266 60019 |
| 29 | TR209, 210 | Transistor, C840Q1, matched pair | 4822 130 40769 |
| 29 | TR211, 212 | Transistor, C840Q1, matched pair | 4822 130 40769 |

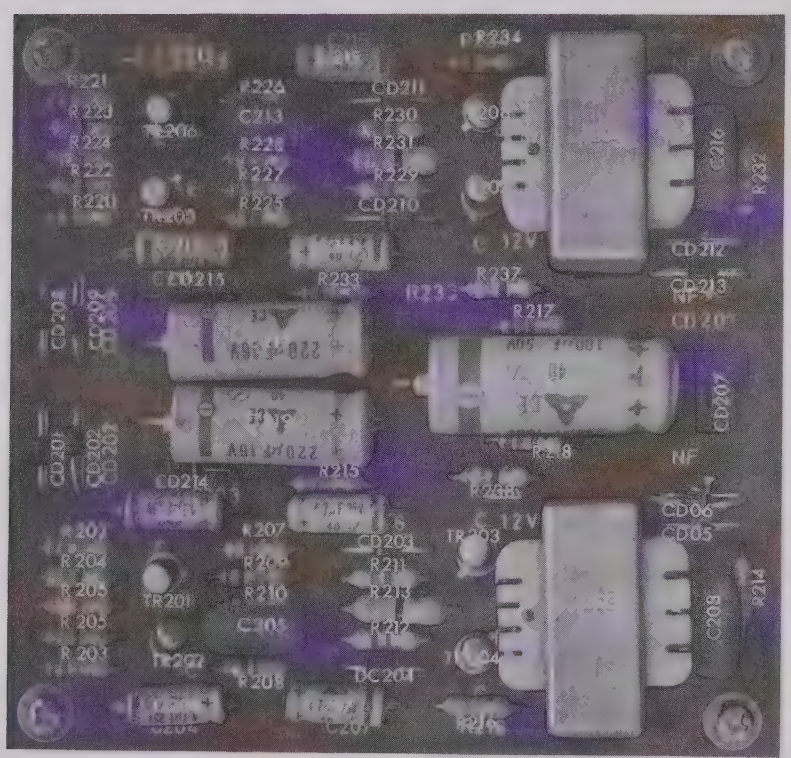



*Fig. 30*

## XI. CHART HOLD MECHANISM

The chart hold mechanism consists in principle of three parts, viz.:

1. High voltage transformer, which delivers the necessary high voltage for the chart table. This transformer is connected to a fixed tapping on the power transformer. The high voltage is fed to the chart table via two rectifier diodes.
2. The chart table itself, which provides the electrostatic field to secure the chart paper (see also chapter VI. PRINCITPLE OF OPERATION).
3. The chart positioning lamps, which are used to position the chart paper so, that the recording lines on the paper run exactly parallel with the X- and Y-axes of the writing system.

The high voltage transformer is removed simply by unsoldering the connections on the printed wiring board and loosening the fixing screws.

When remounting the transformer, connect the wiring as stated in table IV.
The chart table wiring must be connected according to the colours indicated on the printed wiring board.

**Table IV**

| Connection point of printed wiring board | Cable-form | Colour of wire |
|---|---|---|
| 1 | white | red/black mark |
| 2 | white | white/black mark |
| 3 | white | black and black/white (loose wire) |
| 4 | cable-form chart table | yellow |
| 5 | white/yellow | red |
| 6 | cable-form chart table | black |
| 7 | white/yellow | neutral |
| 8 | cable-form chart table | red |
| 9 | loose wire | yellow/white |
| 10 | white/green | white |
| 10 | white/green | white/black mark |
| 11 | white/green | red/black mark |
| 12 | white/green | red |
| 13 | loose wire | yellow/white |

When the lamp holders need replacement, the mounting bar (fig. 31, item a) must be removed by loosening the relevant screws. After removal of the mounting bar, the lamp holders can be unscrewed.

## LIST OF SERVICE PARTS

| Fig. | Item | Description | Service code number |
|---|---|---|---|
| 31 | T101 | High voltage transformer | 4822 148 20084 |
| 31 | PL102, 103 | Lamp holder, with lamp | 4822 134 40261 |
| 31 | CD112, 113 | Diode, ED 01 | 4822 130 30683 |
| 31 | S103 | Switch, "CHART HOLD" | 4822 277 10308 |
| 31 | Ch. T | Chart table | 4822 466 80568 |

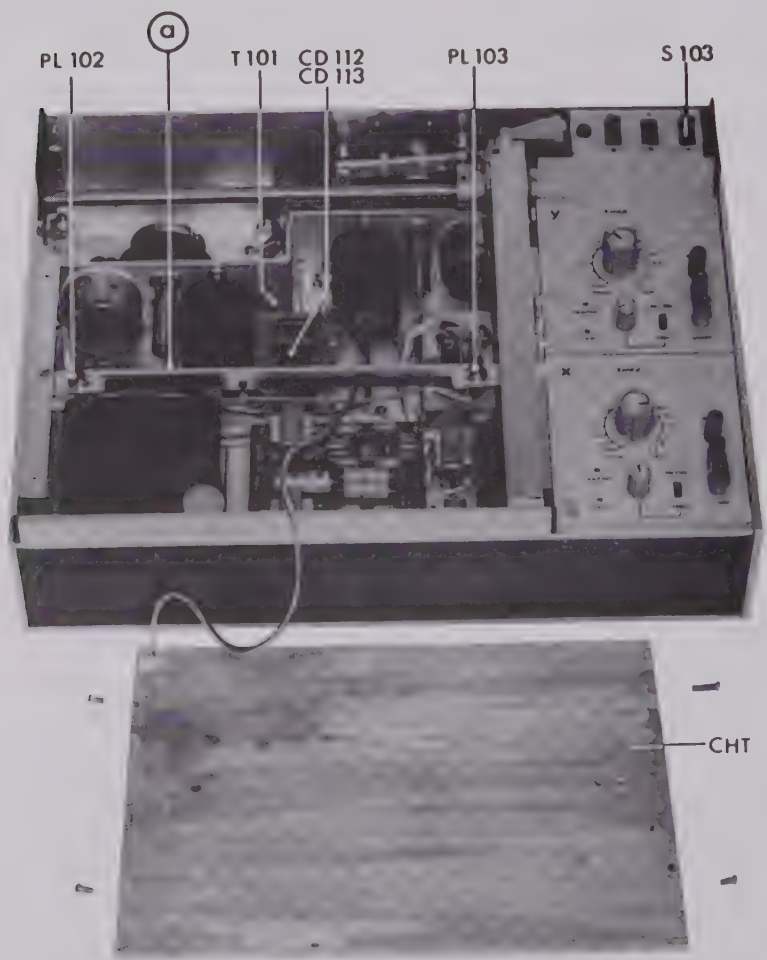



*Fig. 31*

# XII. MEASURING CARRIAGES

## A. X-SYSTEM

The X-measuring carriage, on which the Y-measuring carriage (fig. 34, item 3) slides back and forth, is supported on two points, viz.:
– on the guide shaft, by means of two cylindrical bearings
– at the lower end of the slide bar, by means of a guide wheel which runs in the groove in the front plate (see fig. 32, item c).

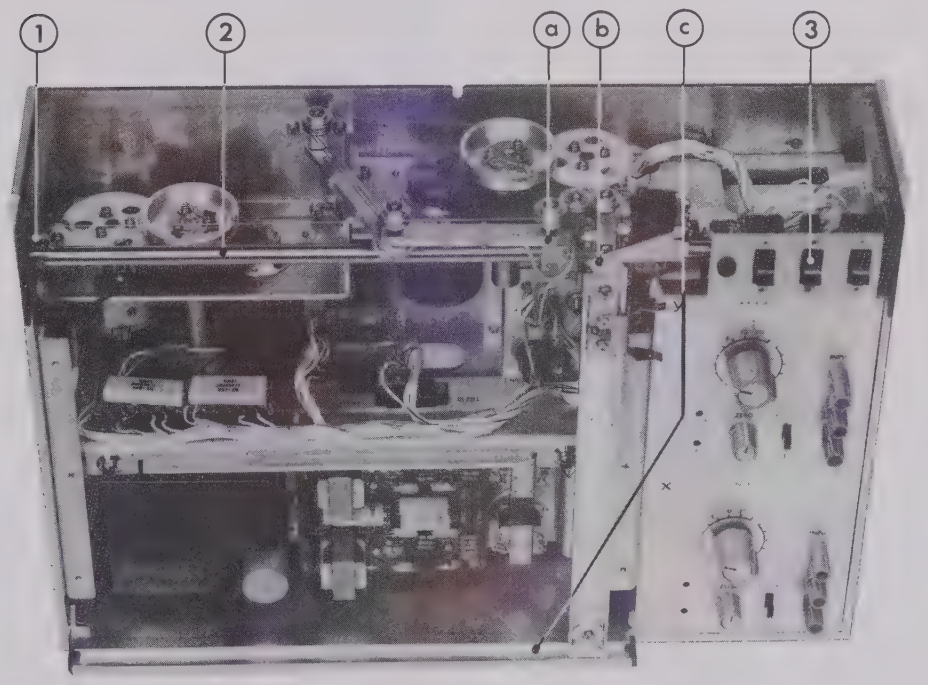



*Fig. 32*

**Replacement of parts**

**1. Guide shaft**

To replace the guide shaft, which is necessary when the surface has been damaged sufficiently to prevent smooth operation of the measuring carriage, proceed as follows:
– Loosen the two large screws on the side plate covers.
– Loosen the four small fixing screws in the corners of the resp. side plate covers, and remove these covers.
– Remove the left-hand accessory plate by loosening the two relevant screws.
– Loosen the fixing screws of the guide shaft (fig. 32, item 2) and take out this shaft.

When remounting the guide shaft, ensure that it runs exactly parallel with the groove in the front plate (fig. 32, item c), so that the measuring carriage can operate smoothly over the full scale.

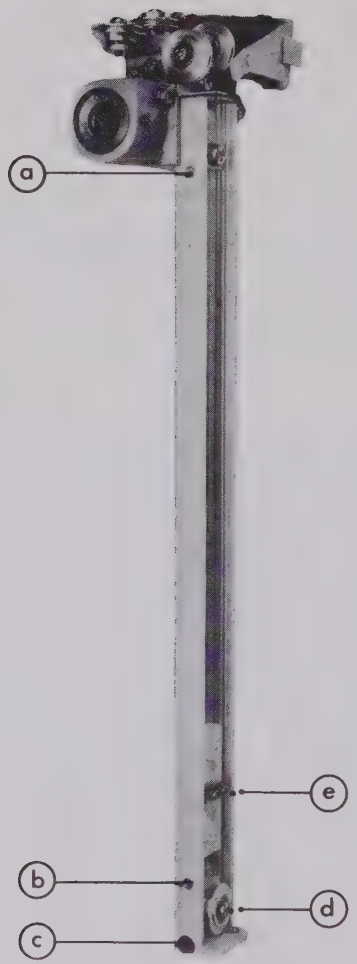



*Fig. 33*

**2. Bearings**

To replace the bearings:
– remove the guide shaft (see above)
– loosen the set screw (fig. 34, item b) and take out the bearing.

**3. Carriage cover assembly (fig. 35, item 8)**

To remove this cover:
– turn the teflon pawl (fig. 32, item b) clockwise until the cover is released.
– push the cover assembly up, note the position of the cover spring and take out the lower hinge point.

**4. Guide wheel**

To replace this nylon wheel, proceed as follows:
– loosen the hinge point of the link assembly (fig. 32, item a)
– remove the carriage cover assembly (see above)
– remove the drive cord guide pulley (fig. 33, item d) by loosening the screw.
– loosen the two fixing screws of the teflon buffer stop (fig. 34, item f)
– push up the buffer stop (fig. 34, item e) and take the guide wheel off its shaft.

**5. Pen lift relay**

The pen lift relay is delivered as an assembly and can be taken off the measuring carriage by unsoldering the wiring and loosening the screws (fig. 34, item a).

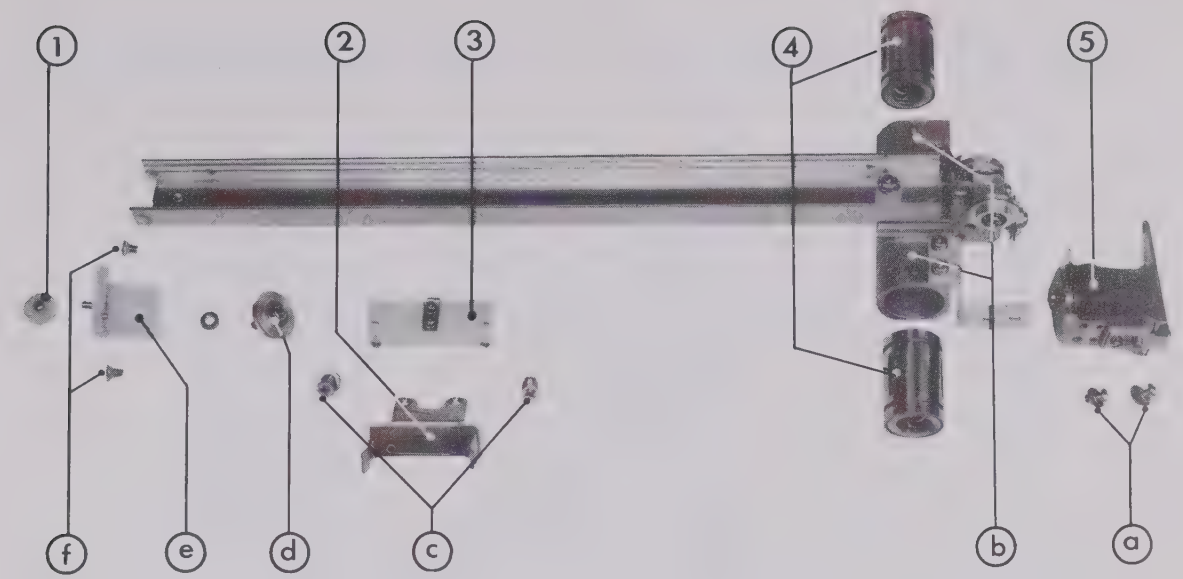



*Fig. 34*

## B. Y-SYSTEM

### 1. Slide bearings

The slide bearings of the Y-measuring carriage can be adjusted by means of two set screws, which are accessible through small holes in the slide bar (fig. 33, item a and b) when the measuring carriage is moved to the extreme upper and lower positions resp.
The bearing pins should be adjusted for minimum play whilst maintaining smooth operation.

### 2. Measuring carriage

To replace the measuring carriage:
– remove the guide wheel (see A.4 of this chapter) and remove the buffer stop.
– slide the measuring carriage off the slide bar.

### 3. Pen holder assembly

Before replacing the pen holder assembly:
– remove the writing system
– turn up the carriage cover assembly, by moving the teflon pawl (fig. 32, item b).
The pen holder assembly is then removed simply by loosening the two fixing screws (fig. 34, item c).

## LIST OF SERVICE PARTS

| Fig. | Item | Description | Service code number |
|---|---|---|---|
| 16 | – | Writing system | 4822 529 30022 |
| 35 | 8 | Carriage cover assy | 4822 693 90265 |
| – | – | Spring for carr. cover assy | 4822 492 40444 |
| 32 | 1 | Damper | 4822 529 10117 |
| 32 | 2 | Guide shaft | 4822 535 90809 |
| 32 | 3 | Switch - "PEN LIFT" | 4822 277 10308 |
| 34 | 1 | Guide wheel, nylon | 4822 528 90198 |
| 34 | 2 | Penholder assy | 4822 693 90266 |
| 34 | 3 | Measuring carriage (Y) | 4822 464 90068 |
| 34 | 4 | Cylindrical bearing | 4822 520 20236 |
| 34 | 5 | Pen lift relay (K101) | 4822 280 40153 |
| 44 | GR111 | Diode, 10D1, for K101 | 4822 130 30169 |
| – | – | Plug, "EXT PEN LIFT", male | 4822 276 30218 |
| – | – | Plug, "EXT PEN LIFT", female | 4822 264 30101 |

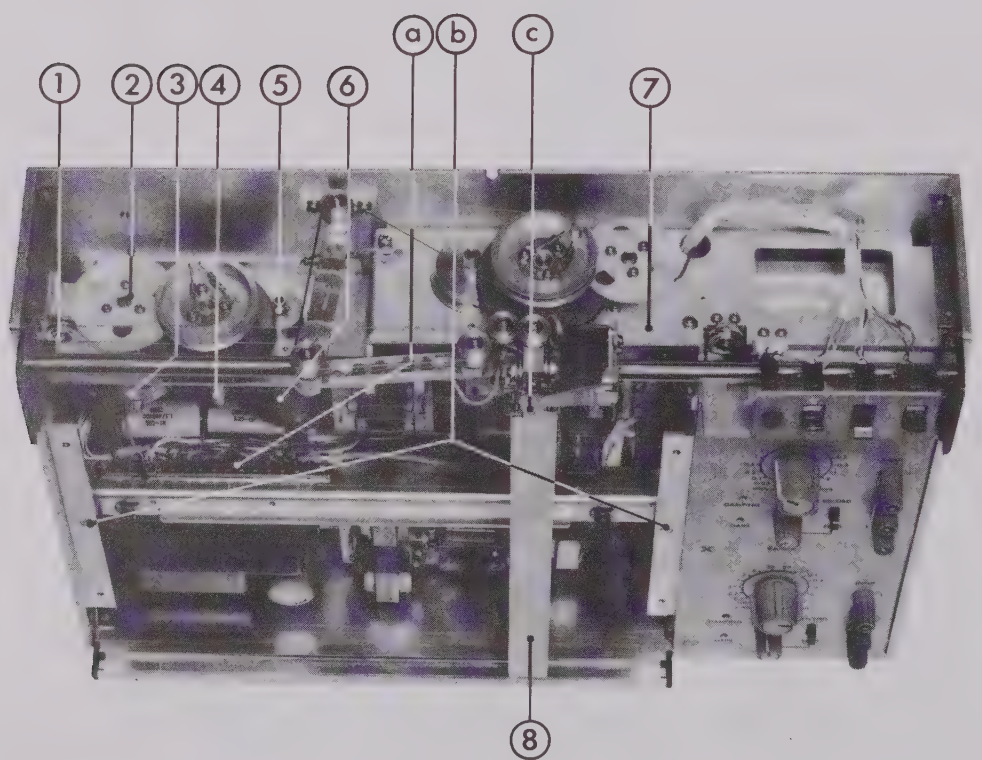



*Fig. 35*

# XIII. DRIVING MECHANISM AND MEASURING POTENTIOMETER, X-SYSTEM

The driving mechanism of the X-system consists of several parts, the most important of which are the servo-motor and the measuring potentiometer.
The power developed by the servo-motor is transmitted to the distributor shaft by a slip-coupling, which prevents overloading the servo-motor when the recording goes off scale.
The measuring potentiometer is coupled to the distribution shaft by a gear transmission.
The measuring carriage is operated by a drive cord, the cord drum being mounted on the distributor shaft.

## A. MEASURING POTENTIOMETER (fig. 35, item 3)

### 1. Dismounting

- Unsolder the wiring
- Loosen the two set screws which secure the potentiometer gear to the shaft (the nylon gear wheel can remain on the coupling bush).
- Loosen the three screws which secure the potentiometer to the mounting bracket. These screws are accessible through the holes in the gear wheel.

### 2. Remounting

Remounting takes place in the reverse order. However, do not tighten the two gear wheel set screws until the potentiometer has been readjusted.
The wiring should be connected according to table V.

Table V

| Colour of wire | Connect to |
|---|---|
| blue | point 1 of potentiometer |
| neutral | point 2 of potentiometer |
| red | point 3 of potentiometer |
| black | grount point (top of mounting bracket) |

### 3. Adjustment

After remounting the measuring potentiometer, the position of the slider must be adjusted with respect to the position of the measuring carriage.
Adjustment is as follows:

- Loosen the two set screws which secure the potentiometer gear to the potentiometer shaft.
- Move the X-measuring carriage to the right-hand end of the scale.
- Turn the potentiometer shaft, by inserting a screwdriver, until the resistance, measured between terminals 1 and 2, is 50-70 Ω.
- Fasten the set screws of the potentiometer gear.
- Check that the resistance measured between terminals 1 and 2 is still 50-70 Ω.

## B. SERVO-MOTOR (fig. 35, item 6)

### 1. Dismounting

– Unsolder the connections of the cable-form on strip TB 101 (fig. 35, item a)
– Remove the power unit (see chapter X-C)
– Loosen the mounting bar by removing the relevant screws (fig. 35, item b)
– Loosen the fixing screws and take out the servo-motor
– Remove the motor pinion, which is fixed to the motor shaft by two set screws.

### 2. Remounting

Remounting takes place in the reverse order.
Connect the cable-form to strip TB 101 according to the circuit diagram (fig. 44).
The motor pinion should engage the slip gear with minimum play, whilst maintaining smooth operation.

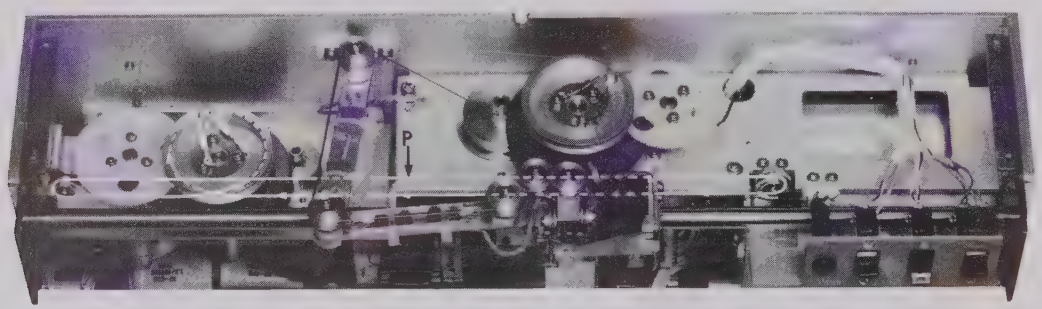



*Fig. 36*

## C. TRANSMISSION CIRCUIT

The transmission circuit consists of the motor pinion, distributor shaft, potentiometer gear and the drive cord, with associated parts.
The slip gear, slip bush and the cord drum are mounted on the distributor shaft.

### 1. Motor pinion (fig.35, item 5)

The servo-motor pinion can be replaced only when either the servo-motor, or the slip gear has been removed from the recorder.
The easiest way to replace the pinion is to remove the servo-motor, since this does not disturb the distributor shaft and the drive cord.

### 2. Potentiometer gear

The potentiometer gear is removed simply by loosening the three screws securing it to the coupling bush (fig. 38, items a).
When remounting the gear, ensure that it engages the gear on the distributor shaft with minimal play.
After remounting the gear wheel, readjustment of the potentiometer is necessary. For this, see part A.3 of this chapter.

### 3. Distributor shaft assembly (fig. 37)

To replace this part, proceed as follows:
– Remove the drive cord by loosening the screw (fig.38, item b) on the cord tensioner and the fixing screw on the measuring carriage.
– Loosen the two potentiometer gear set screws
– Remove the distributor shaft locking ring (fig. 37, item a) and pull out the potentiometer gear together with the shaft assembly.

Further disassembling is effected according to fig. 37.
The cord tensioner should be remounted in the position, indicated in fig. 38.

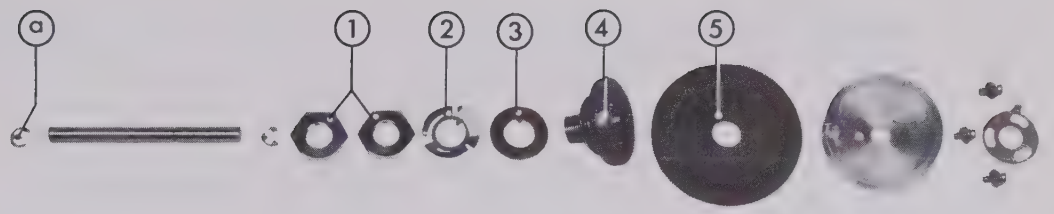



*Fig. 37*

After remounting the distributor shaft assembly, readjustment of the measuring potentiometer is necessary. For this, refer to part A.3 of this chapter.
Readjustment of the slip-coupling is also necessary. For this adjustment, the data are stated below.

**4. Slip-coupling**

The slip-coupling is disassembled as indicated in fig. 37.
To adjust the slip moment, proceed as follows:
– Switch on the recorder.
– Set the "ZERO-RECORD" switches to the "ZERO" positions.
– Move the X-measuring carriage to approx. the center of the scale, by means of the "ZERO" potentiometer.
– Connect an a.c. voltmeter between points 5 and 6 of strip TB 101.
– Move the measuring carriage by hand away from its zero point until the coupling just starts slipping. The reading of the voltmeter should be 5-6 V.
If not, adjust the position of the hexagonal nuts until the reading is correct.

**5. Drive cord**

To remove the cord:
– remove the cord end from the lip on the cord tensioner.
– loosen the fixing screw on the cord tensioner (fig. 38, item b) and on the measuring carriage.

Remount the drive cord as follows:
– fix one end of the cord to the cord tensioner by means of the fixing screw (fig. 38, item b).
– lead the free end of the cord across the guide pulleys, as indicated in fig. 36.
– lead the cord twice across the cord drum and fix it to the lip of the cord tensioner.
– move the X-measuring carriage to the right-hand end of the scale.
– move the cord drum to the position, indicated in fig. 38.
– fix the cord to the measuring carriage by means of the relevant screw on the carriage.
– push the cord, by means of a spring tension meter, to the inner frame until it just touches this frame at point P (fig. 36).
The tension measured should be 40 ± 5 grams. If not, move the cord tensioner until the tension is correct (clockwise rotation increases the tension).

After replacing the drive cord, readjustment of the measuring potentiometer is necessary. This adjustment is described in part A.3 of this chapter.

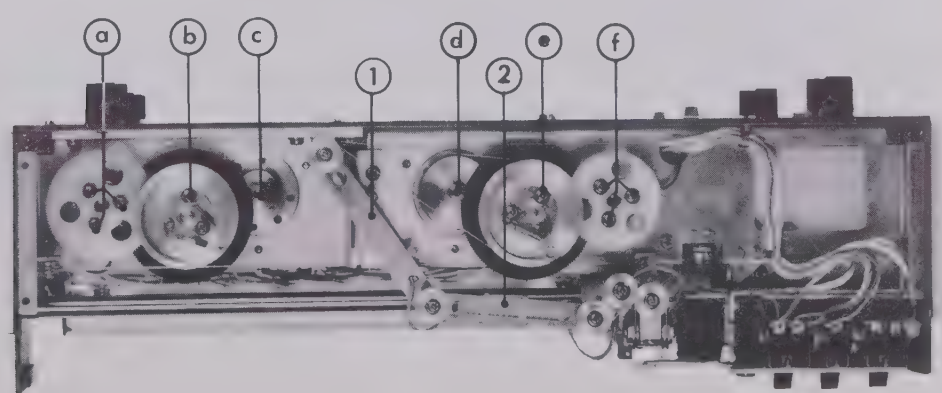



*Fig. 38*

### 6. Guide pulley assembly

The guide pulley assemblies are removed by loosening the cross-head screw which secures them to the frame.

## LIST OF SERVICE PARTS

| Fig. | Item | Description | Service code number |
|---|---|---|---|
| 34 | 1 | Guide pulley | 4822 528 80458 |
| 37 | 1 | Hexagonal nut | 4822 505 10503 |
| 37 | 2 | Slip spring | 4822 492 61687 |
| 37 | 3 | Washer | 4822 532 10594 |
| 37 | 4 | Slip bush | 4822 522 31076 |
| 37 | 5 | Slip gear | 4822 522 31075 |
| 39 | 1 | Measuring potentiometer | 4822 103 20225 |
| 39 | 2 | Potentiometer gear | 4822 522 31076 |
| 39 | 3 | Holder, with bearings | 4822 520 30256 |
| 39 | 4 | Motor pinion | 4822 522 31071 |
| 39 | 5 | Servomotor | 4822 361 60167 |

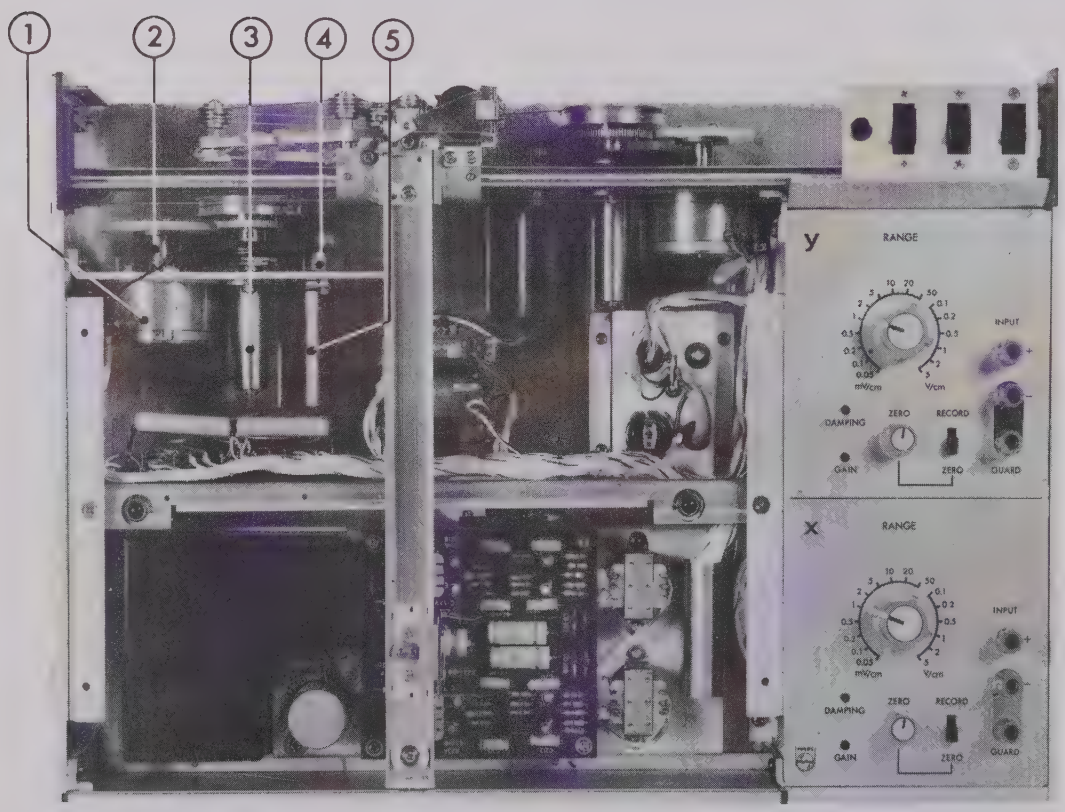



*Fig. 39*

# XIV. DRIVING MECHANISM AND MEASURING POTENTIOMETER, Y-SYSTEM

The driving mechanism of the Y-system is similar to that of the X-system. The difference is, that the Y-measuring carriage is situated on the X-measuring carriage, which necessitates a flexible cord guidance system. This is provided by mounting the guide pulleys of the drive cord on two pivoting levers, which allow the X-measuring carriage to move over the full scale without altering the cord tension of the Y-system.

## A. MEASURING POTENTIOMETER (fig. 40, item 5)

### 1. Dismounting

- Unsolder the wiring.
- Loosen the two set screws which secure the potentiometer gear to the shaft (the nylon gear wheel can remain on the coupling bush).
- Loosen the three screws which secure the potentiometer to the mounting bracket. These are accessible through the holes in the gear wheel.

### 2. Remounting

Remounting takes place in the reverse order. However, do not tighten the two gear wheel set screws until the potentiometer has been readjusted.
The wiring should be connected according to table VI.

**Table VI**

| Colour of wire | Connect to |
|---|---|
| blue | point 1 of potentiometer |
| neutral | point 2 of potentiometer |
| red | point 3 of potentiometer |
| black | ground point (top of mounting bracket) |

### 3. Adjustment

After replacing the measuring potentiometer, the position of the slider must be adjusted with respect to the position of the measuring carriage.
Adjustment as follows:

- Loosen the two set screws which secure the gear to the potentiometer shaft.
- Move the Y-measuring carriage to the lower end of the scale.
- Turn the potentiometer shaft, by inserting a screwdriver, until the resistance, measured between terminals 1 and 2 is 50-70 Ω.
- Fasten the set screws of the potentiometer gear.
- Check that the resistance between terminals 1 and 2 is still 50-70 Ω.

## B. SERVO-MOTOR

### 1. Dismounting

- Unsolder the connections of the cable-form on strip TB101 (fig. 35, item a).
- Loosen the fixing screws of the high voltage transformer.
- Loosen the fixing screws of the servo-motor and take it out.
- Remove the motor pinion, which is fixed to the motor shaft by two set screws.

### 2. Remounting

Remounting takes place in the reverse order.
Connect the cable-form to strip TB101 according to the basic diagram (fig. 44).
The motor pinion should engage the slip gear with minimum play, whilst maintening smooth operation.

## C. TRANSMISSION CIRCUIT

The transmission circuit consists of the motor pinion, distributor shaft, potentiometer gear and the drive cord, with associated parts.
The slip gear, slip bush and cord drum are mounted on the distributor shaft.
For replacement instructions of the motor pinion, distributor shaft and potentiometer gear, refer to chapter XIII-C.

### 1. Slip-coupling

For disassembling instructions of the slip-coupling, refer to chapter XIII-C.4.
The adjustment procedure of the slip-coupling of the Y-system is similar to that of the X-system, with the difference that the voltage on the motor should be measured between points 12 and 13 of strip TB101 (see XIII-C.4).

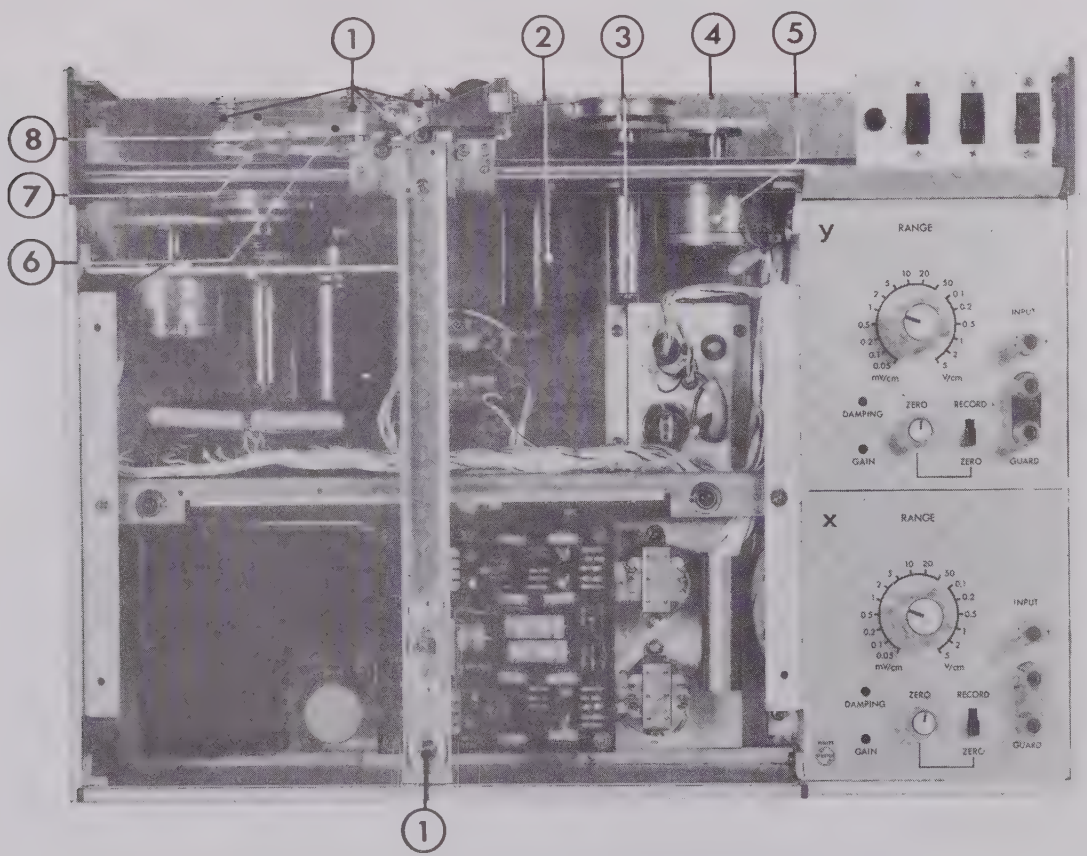



*Fig. 40*

**2. Drive cord (fig. 40, item 8)**

To remove the cord:
– remove the writing system.
– turn up the carriage cover assembly by moving the teflon pawl (fig. 40, item e) clockwise.
– loosen the fixing screw on the cord tensioner (fig. 38, item e), and the fixing screws on the measuring carriage. (fig. 33, item e).

Remount the drive cord as follows:
– fix one end of the cord to the cord tensioner, with the aid of the fixing screw (fig. 38, item e).
– lead the free end across the cord drum and across the guide pulleys, as indicated in fig. 41.
– fix the cord to the lip on the cord tensioner.
– move the cord drum to the position, indicated in fig. 38.
– move the measuring carriage to the upper end of the scale and fix the cord to it by fastening the two screws (fig. 33, item e).
– move the X-measuring carriage to bring the longer link assembly (fig. 38, item 1) perpendicular to the guide shaft.
– push the cord at point Q in fig. 41, by means of a spring tension meter, until it just touches the cord running parallel. The reading on the spring tension meter should be 30 ± 5 grams. If not, move the cord tensioner until the reading is correct (clockwise rotation increases the tension).

After replacing the drive cord, the measuring potentiometer must be readjusted. For this adjustment, refer to part A.3 of this chapter.

**3. Link assemblies (fig. 40, item 6 and 7)**

To remove the link assemblies:
– remove the drive cord (see above).
– remove the guide pulleys by loosening the resp. crosshead screws.
– loosen the hexagonal bolts, located under the guide pulleys and take out the link assemblies.

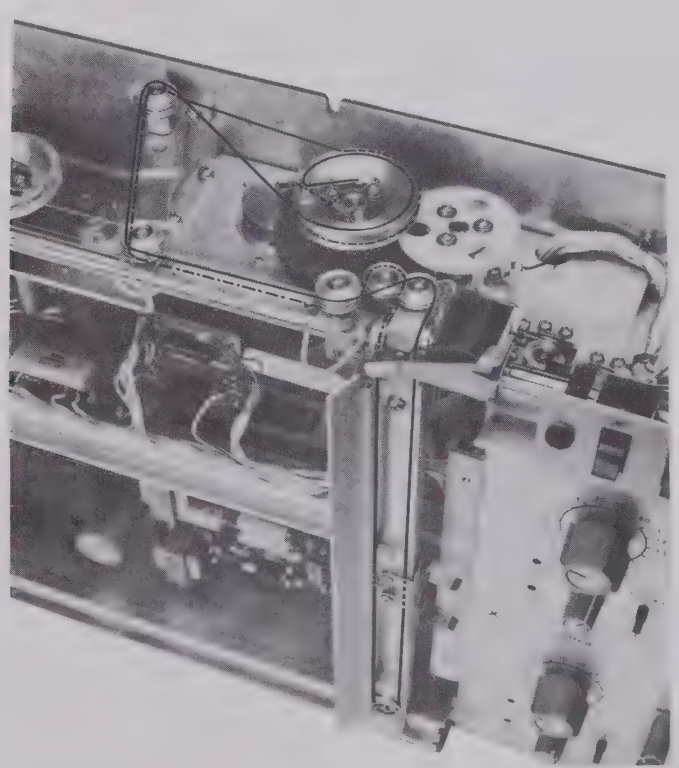


*Fig. 41*

## LIST OF SERVICE PARTS

| Fig. | Item | Description | Service code number |
|---|---|---|---|
| 37 | 1 | Hexagonal nut | 4822 505 10503 |
| 37 | 2 | Slip spring | 4822 492 61687 |
| 37 | 3 | Washer | 4822 532 10594 |
| 37 | 4 | Slip bush | 4822 522 31073 |
| 37 | 5 | Slip gear | 4822 522 31075 |
| 40 | 1 | Guide pulley assy | 4822 528 80458 |
| 40 | 2 | Servo-motor | 4822 361 60167 |
| – | – | Motor pinion | 4822 522 31072 |
| 40 | 3 | Holder, with bearings | 4822 520 30256 |
| 40 | 4 | Potentiometer gear | 4822 522 31074 |
| 40 | 5 | Measuring potentiometer | 4822 103 20225 |
| 40 | 6 | Link assembly, short | 4822 466 80566 |
| 40 | 7 | Link assembly, long | 4822 466 80567 |
| 40 | 8 | Drive cord | 4822 321 30134 |

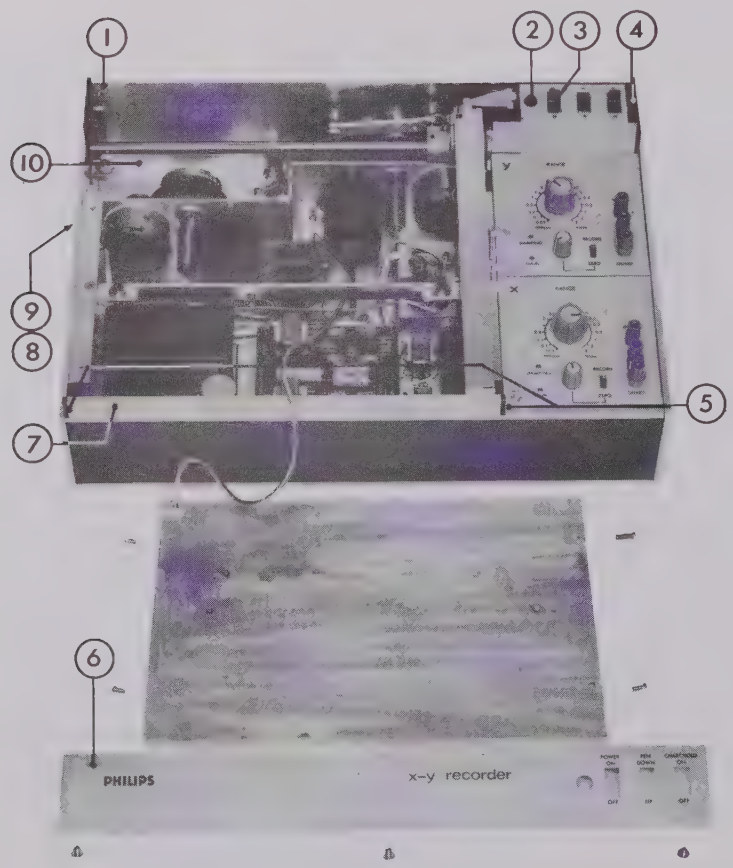



*Fig. 42*

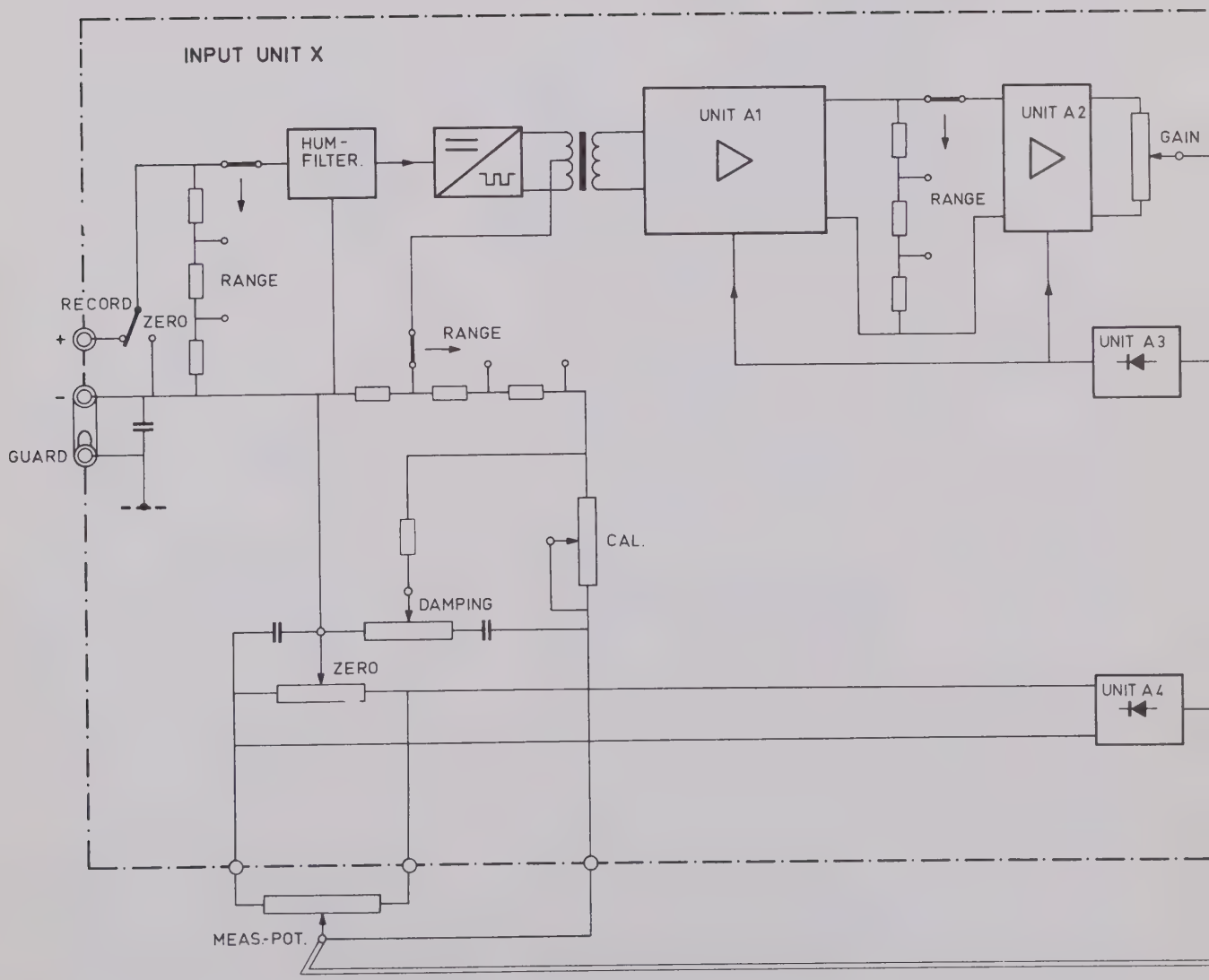
## XV. FRAME

Replacement of front, side, rear and accessory plates:
To remove the side-plates, first remove the side plate covers by loosening the relevant screws.
To replace the rear plate:
– remove the input units (see ch. III.A)
– remove the chart table
– remove the power unit (see ch. X.C)
– remove the hood (fig. 42, item 6)
– loosen the relevant screws of the rear plate.

To replace the front plate assembly: (fig. 42, item 7)
– remove the side plate covers (fig. 42, item 8)
– remove the chart table
– loosen the two lower fixing screws of each side plate
– loosen the three lower fixing screws of the rear plate and take out the front plate assembly.

### LIST OF SERVICE PARTS

| Fig. | Item | Description | Service code number |
|---|---|---|---|
| 42 | 1 | Accessory plate, left | 4822 466 80564 |
| 42 | 2 | Pilot lamp (PL 101) | 4822 134 20101 |
| 42 | 3 | Switch, "POWER ON" (S 101) | 4822 277 10308 |
| 42 | 4 | Accessory plate, right | 4822 466 80565 |
| 42 | 5 | End accessory, for front plate | 4822 466 80659 |
| 42 | 6 | Hood | 4822 455 90392 |
| 42 | 7 | Front plate assy | 4822 466 80561 |
| 42 | 8 | Side plate cover | 4822 466 80563 |
| 42 | 9 | Side plate, left and right | 4822 466 80562 |
| 42 | 10 | Rear plate | 4822 466 80559 |
| | | Plastic foot, right | 4822 462 70756 |
| | | Plastic foot, left | 4822 462 70757 |
| | | Bail tilt | 4822 404 50565 |
| | | Dust cover | 4822 600 30003 |
| | | Mains cable, per meter | 4822 323 40003 |
| | | Euro contact plug | 4822 264 30007 |


INPUT UNIT X
HUM-
FILTER.
UNIT A1
UNIT A2
GAIN
RANGE
RANGE
RECORD
ZERO
RANGE
UNIT A3
+
-
GUARD
CAL.
DAMPING
ZERO
UNIT A4
MEAS.-POT.

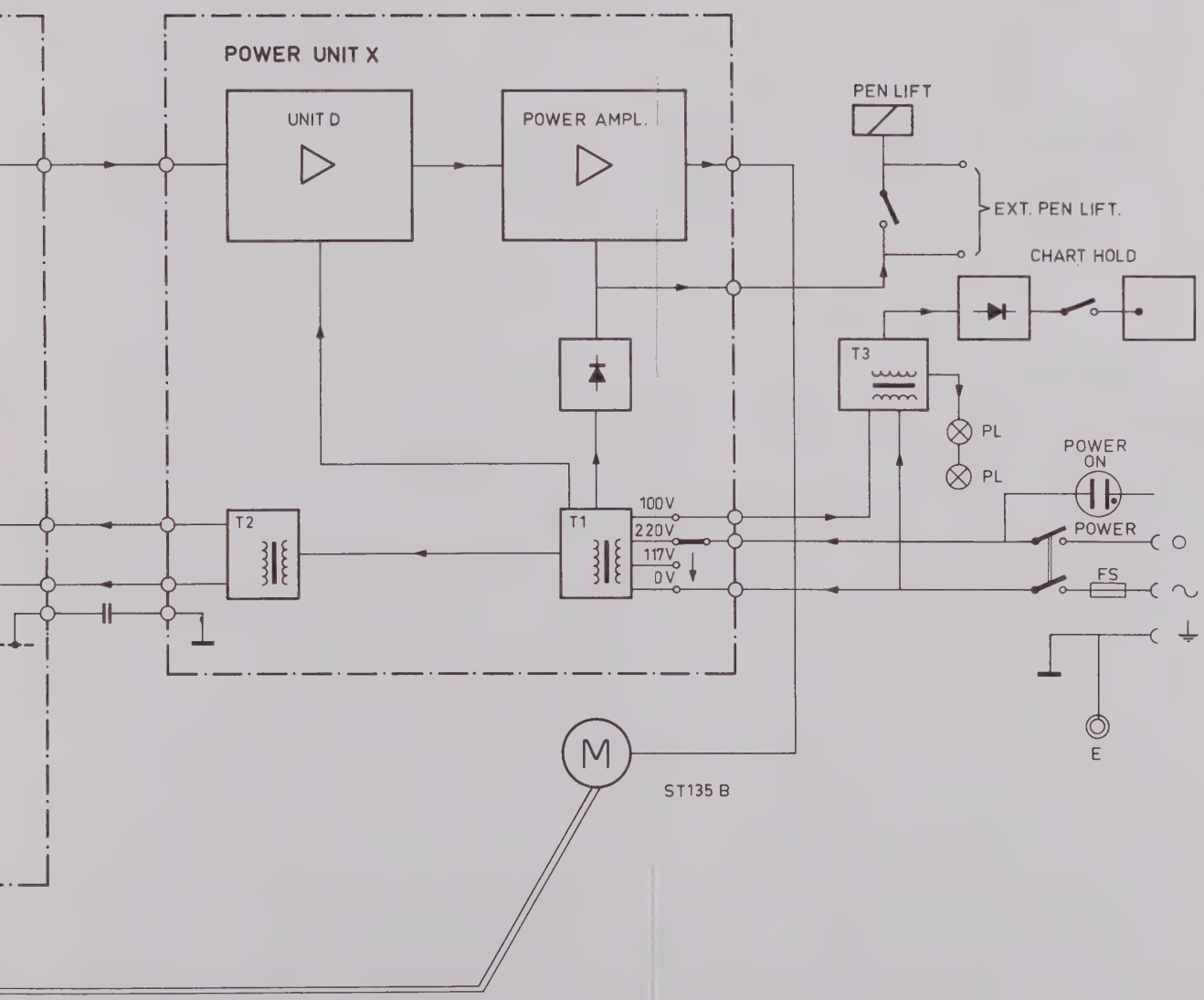

POWER UNIT X
UNIT D
POWER AMPL.
PEN LIFT
EXT. PEN LIFT.
CHART HOLD
T3
PL
PL
POWER
ON
POWER
FS
T2
T1
100V
220V
117V
0V
M
ST135 B
E

*Fig. 43*

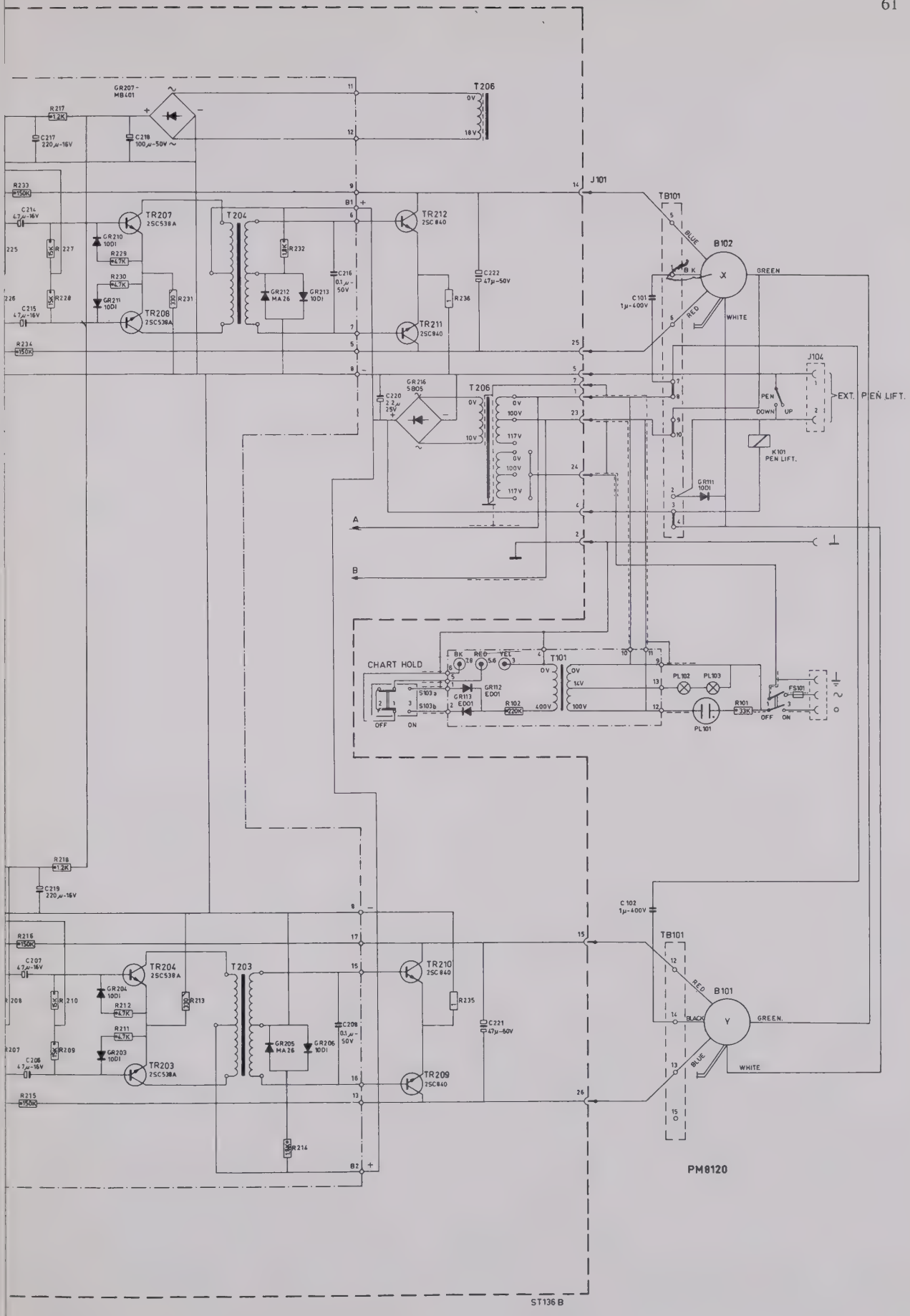

GR207-MB401
T206
R217 1.2K
C217 220μ-16V
C218 100μ-50V
0V
18V
R233 150K
C214 47μ-16V
TR207 2SC538A
GR210 10D1
R229 4.7K
R230 4.7K
GR211 10D1
TR208 2SC538A
R227 15K
R228 15K
R231 330
C215 47μ-16V
R234 150K
T204
R232 1.8K
GR212 MA26
GR213 10D1
C216 0.1μ-50V
TR212 2SC840
TR211 2SC840
R236
C222 47μ-50V
J101
TB101
B102
BLUE
BK
GREEN
RED
WHITE
C101 1μ-400V
J104
EXT. PEN LIFT.
PEN DOWN UP
K101 PEN LIFT.
GR111 10D1
GR216 5B05
C220 2.2μ 25V
0V 100V 117V 10V
A
B
CHART HOLD
BK RED YEL
S103a S103b OFF ON
GR112 ED01
GR113 ED01
T101
0V 14V 100V 400V
R102 220K
PL102 PL103 PL101
R101 33K
FS101 OFF ON
R218 1.2K
C219 220μ-16V
R216 150K
C207 47μ-16V
TR204 2SC538A
GR204 10D1
R212 4.7K
R211 4.7K
GR203 10D1
TR203 2SC538A
R210 15K
R209 15K
C208 47μ-16V
T203
R213 330
GR205 MA26
GR206 10D1
C208 0.1μ-50V
TR210 2SC840
TR209 2SC840
R235
C221 47μ-50V
R214 1.8K
R215 150K
B2
C102 1μ-400V
TB101
B101
RED
BLACK
GREEN
BLUE
WHITE
PM8120
ST136B

*Fig. 44*

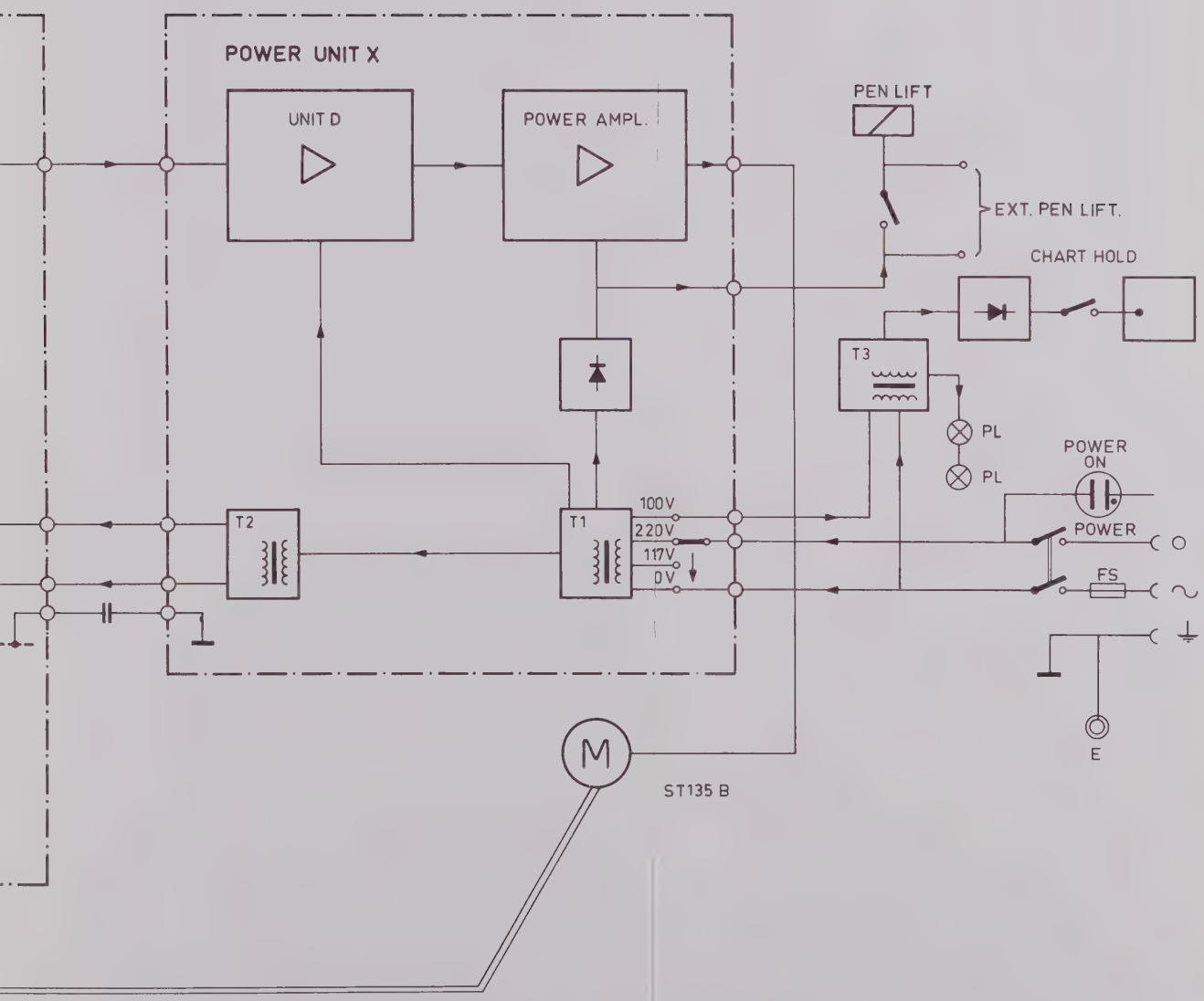
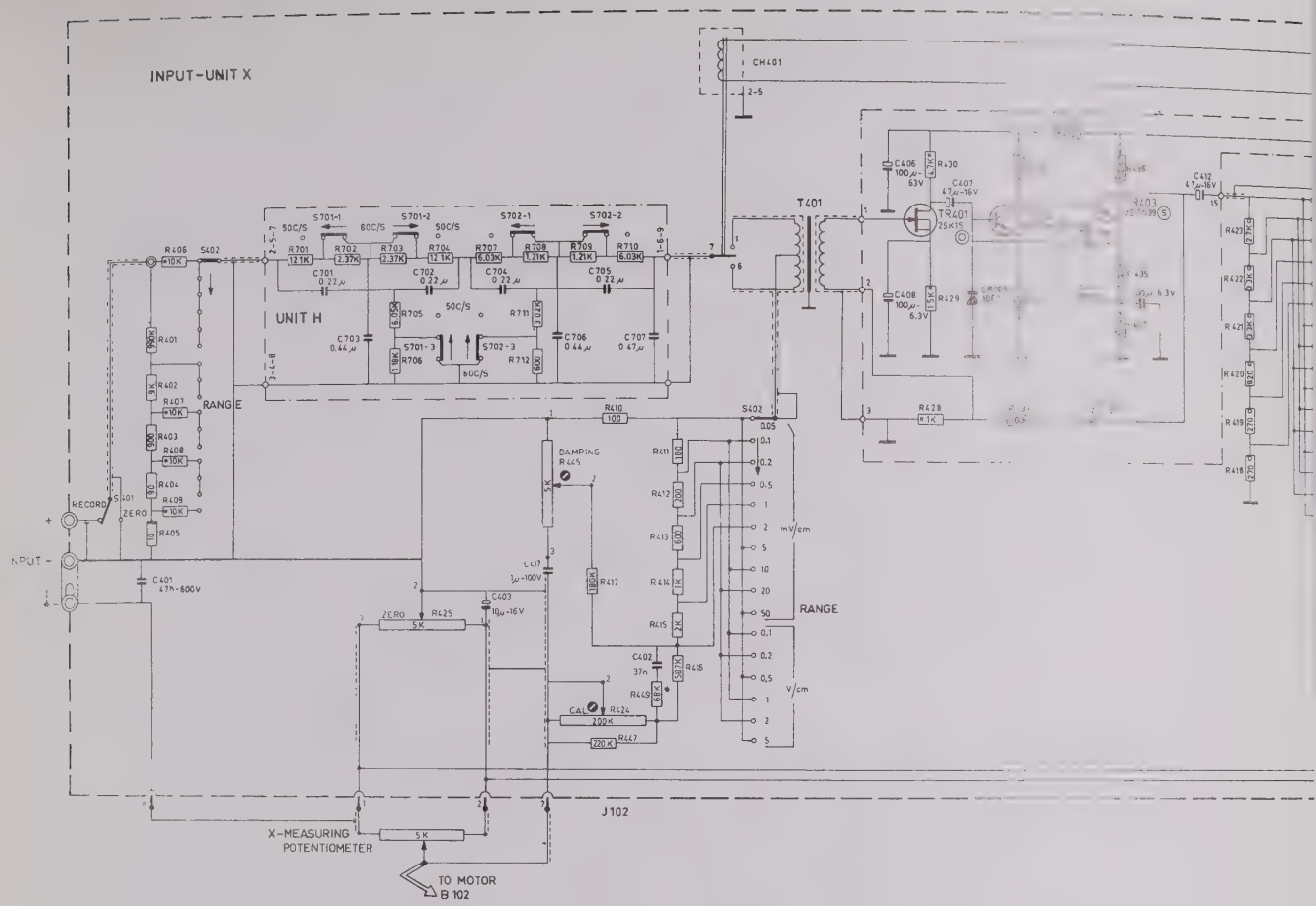
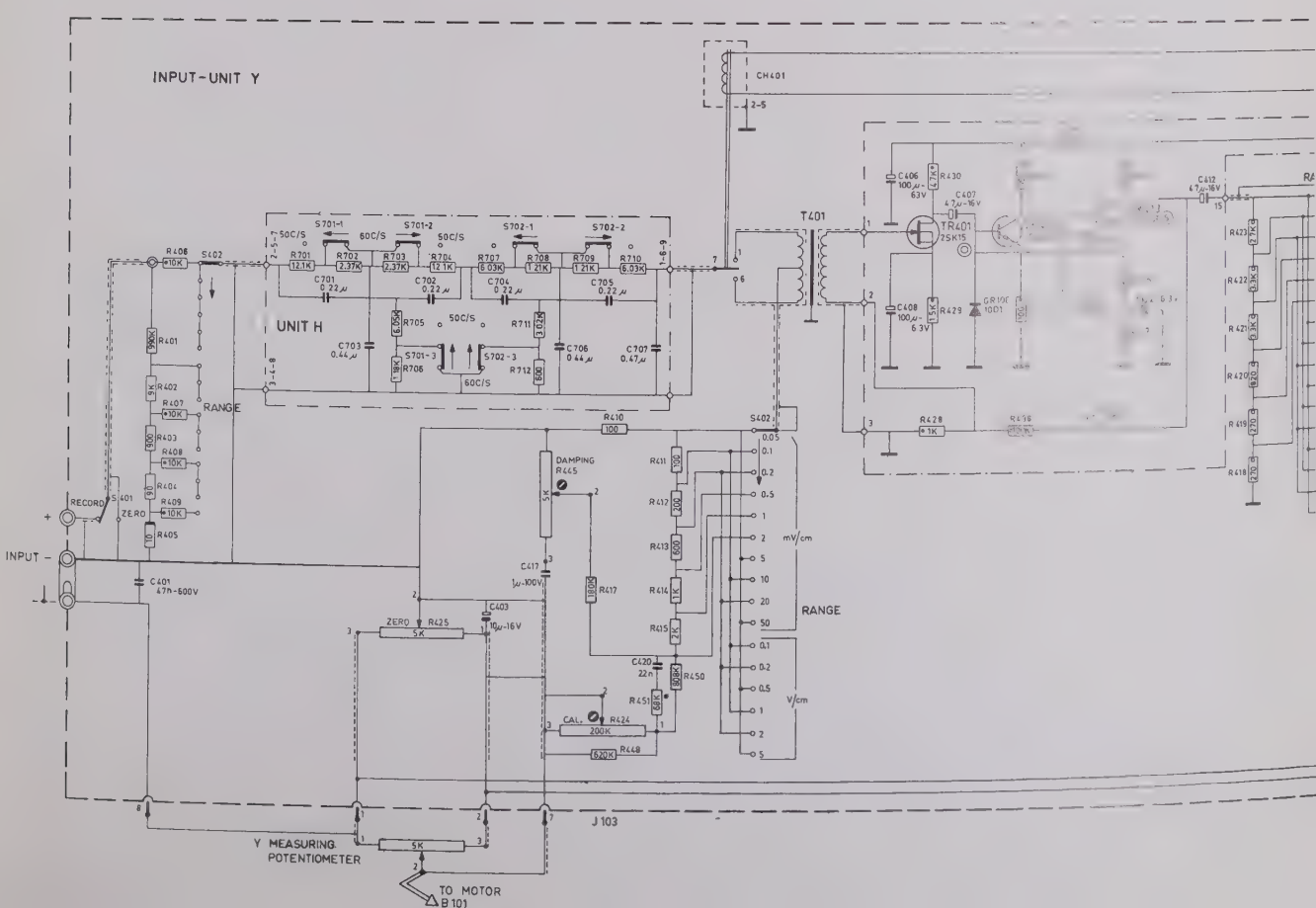
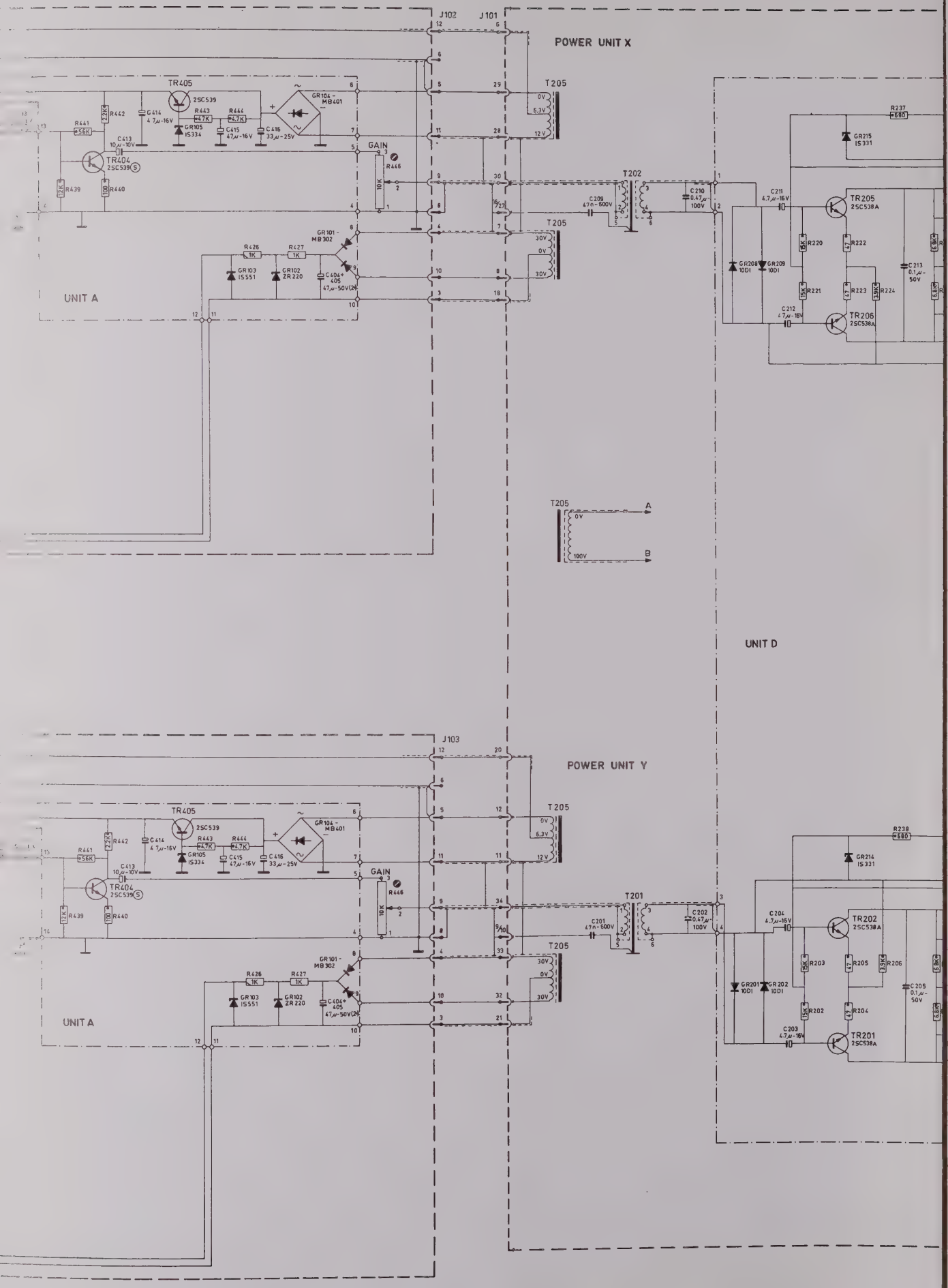

POWER UNIT X
UNIT D
POWER AMPL.
PEN LIFT
EXT. PEN LIFT.
CHART HOLD
T3
PL
PL
POWER
ON
POWER
FS
T2
T1
100V
220V
117V
0V
M
ST135 B
E

*Fig. 43*


INPUT-UNIT X
UNIT H
CH401
T401
TR401
2SK15
S701-1
S701-2
S701-3
S702-1
S702-2
50C/S
60C/S
RANGE
DAMPING
R445
ZERO
R425
CAL.
R424
RECORD
S401
INPUT -
C401
47n-600V
X-MEASURING
POTENTIOMETER
5K
TO MOTOR
B 102
J102
mV/cm
V/cm


INPUT-UNIT Y
UNIT H
CH401
T401
TR401
2SK15
S701-1
S701-2
S701-3
S702-1
S702-2
50C/S
60C/S
RANGE
DAMPING
R445
ZERO
R425
CAL.
R424
RECORD
S401
INPUT -
C401
47n-600V
Y MEASURING.
POTENTIOMETER
5K
TO MOTOR
B 101
J103
mV/cm
V/cm


POWER UNIT X
J102
J101
TR405
2SC539
GR104 - MB401
R441 56K
R442 2.2K
C414 4.7µ-16V
R443 4.7K
R444 4.7K
GR105 IS334
C415 47µ-16V
C416 33µ-25V
C413 10µ-10V
TR404 2SC539(S)
R439 12K
R440 100
GAIN
R446 10K
T205
0V
6.3V
12V
30V
0V
30V
R426 1K
R427 1K
GR101 - MB302
GR103 IS551
GR102 ZR220
C404+ 405 47µ-50V
UNIT A
T202
C209 47n-600V
C210 0.47µ-100V
R237 680
GR215 IS331
C211 4.7µ-16V
TR205 2SC538A
R220 15K
R222 47
R221 15K
R223 47
R224 3.9K
C213 0.1µ-50V
GR208 10DI
GR209 10DI
C212 4.7µ-16V
TR206 2SC538A
T205
A
0V
100V
B
UNIT D
J103
POWER UNIT Y
TR405
2SC539
GR104 - MB401
R441 56K
R442 2.2K
C414 4.7µ-16V
R443 4.7K
R444 4.7K
GR105 IS334
C415 47µ-16V
C416 33µ-25V
C413 10µ-10V
TR404 2SC539(S)
R439 12K
R440 100
GAIN
R446 10K
T205
0V
6.3V
12V
30V
0V
30V
R426 1K
R427 1K
GR101 - MB302
GR103 IS551
GR102 ZR220
C404+ 405 47µ-50V
UNIT A
T201
C201 47n-600V
C202 0.47µ-100V
R238 680
GR214 IS331
C204 4.7µ-16V
TR202 2SC538A
R203 15K
R205 47
R206 4.3K
C205 0.1µ-50V
GR201 10DI
GR202 10DI
R202 15K
R204 47
C203 4.7µ-16V
TR201 2SC538A

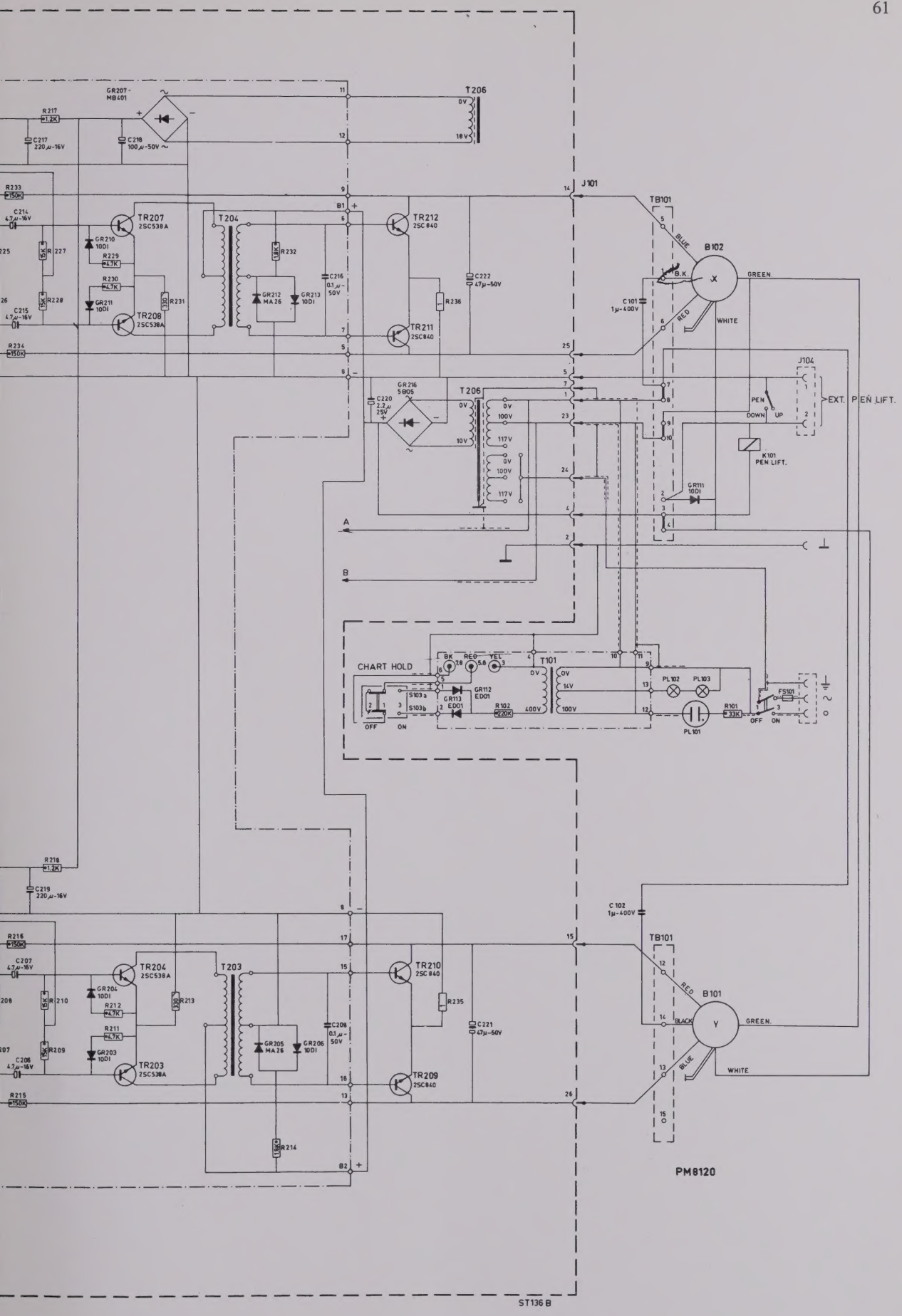

GR207 - MB401
T206
0V
18V
R217 1.2K
C217 220µ-16V
C218 100µ-50V
J101
TB101
B102
BLUE
B.K.
GREEN.
WHITE
RED
C101 1µ-400V
R233 150K
C214 4.7µ-16V
TR207 2SC538A
TR208 2SC538A
GR210 10D1
GR211 10D1
R229 4.7K
R230 4.7K
R227 1K
R228 1K
R231 330
T204
GR212 MA26
GR213 10D1
R232 1.8K
C216 0.1µ-50V
TR212 2SC840
TR211 2SC840
C222 47µ-50V
R236
R234 150K
C215 4.7µ-16V
J104
EXT. PEN LIFT.
PEN
DOWN
UP
K101 PEN LIFT.
GR111 10D1
C220 2.2µ 25V
GR216 5805
T206
0V
100V
117V
10V
A
B
CHART HOLD
BK
RED
YEL
T101
0V
14V
100V
S103a
S103b
OFF
ON
GR112 ED01
GR113 ED01
R102 220K
400V
PL102
PL103
PL101
R101 33K
FS101
OFF
ON
C102 1µ-400V
TB101
B101
RED
BLACK
GREEN.
BLUE
WHITE
R218 1.2K
C219 220µ-16V
R216 150K
C207 4.7µ-16V
TR204 2SC538A
TR203 2SC538A
GR204 10D1
GR203 10D1
R212 4.7K
R211 4.7K
R210 1K
R209 1K
R213 330
T203
GR205 MA26
GR206 10D1
C208 0.1µ-50V
TR210 2SC840
TR209 2SC840
R235
C221 47µ-50V
C206 4.7µ-16V
R215 150K
R214 1.8K
ST136 B
PM8120

*Fig. 44*

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